Human Chem-ical Thermo-Dyn mics

26-elements

92-elements

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284

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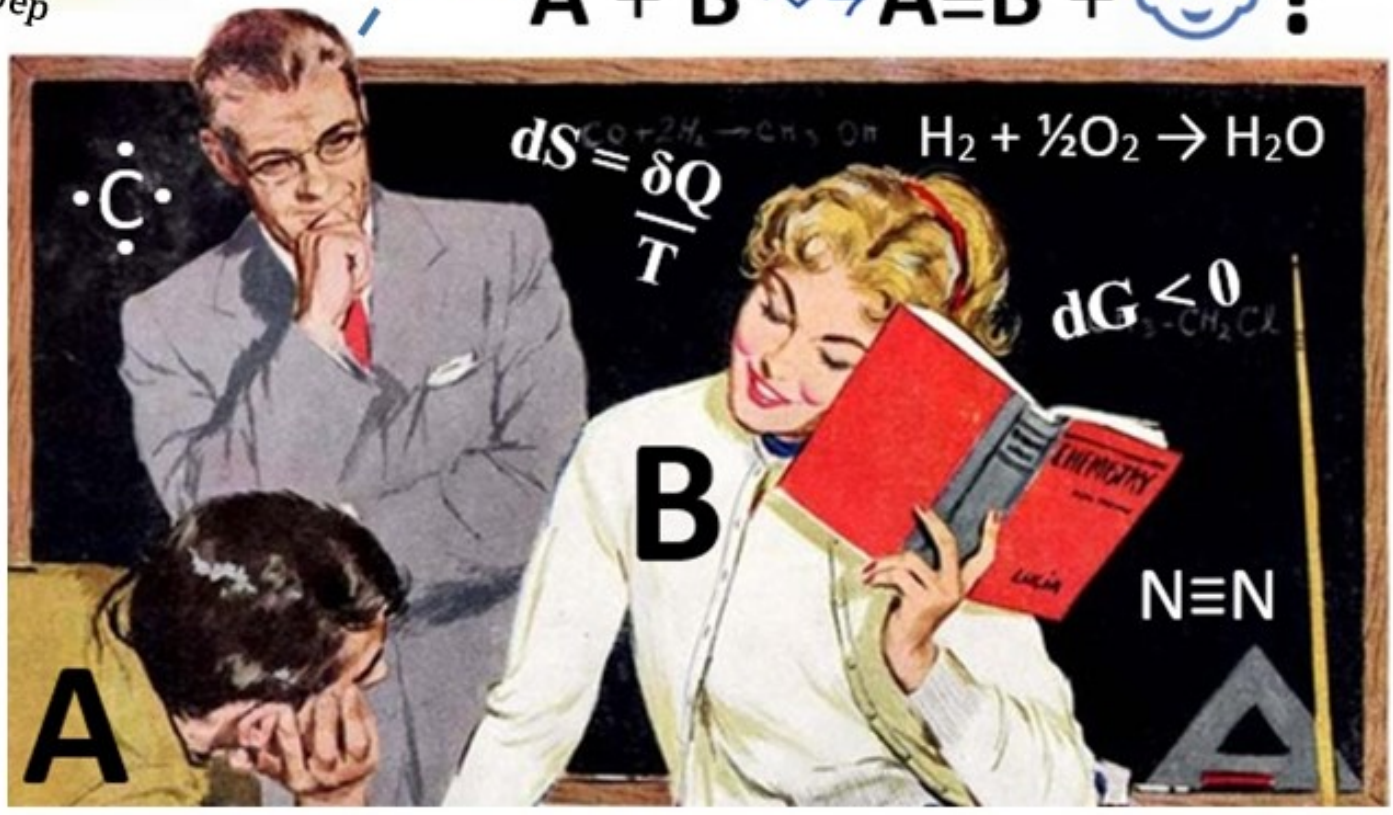

Libb Thims

“Every **thing** in this universe has its regular waves and tides. Electricity, sound, the wind, and I believe every part of organic nature will be brought someday within this law. The laws which govern *animated* beings will be ultimately found to be at bottom the same with those which rule *inanimate* nature, and as I entertain a **profound conviction** of the littleness of our kind, and of the curious enormity of creation [synthesis], I am quite ready to receive with pleasure any basis for a **systematic conception of it all**. I look for regular tides in the affairs of man, and, of course, in our **own affairs**. In ever progression, somehow or other, the nations move by the same [physico-chemical] process which has never been explained but is evident in the oceans and the air. On this theory, I should expect, at about this time, a turn which would **carry us backward**.”

— Henry Adams (1864), ‘Letter to Charles Gaskell’, Oct

Human Chemical Thermodynamics

Morals, Religion, Aesthetics, Feelings, Emotions, Affairs, Society, Civilization, and Individualism

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Human Chemical Thermodynamics
Morals, Religion, Aesthetics, Feelings, Emotions, Affairs, Society, Civilization, and Individualism

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AE = 'After Elements' were first seen by the human eye (by Erwin Muller on 11 Oct 1955)
ACM = 'After Christ Myth' or years since the *Roman recension* of the Osiris-Horus Ra myth

LuLu

Contents

"If we say, in the words of Maxwell some years ago (*Nature*, 1878), that **thermodynamics** is 'a science with secure foundations, clear definitions, and distinct boundaries', and ask when those **foundations were laid**, those definitions fixed, and those boundaries traced, there can be but one answer. Certainly **not before the publication of Clausius**' 1850 memoir 'On the Motive Power of Heat and the Laws of Heat Which May be Deduced Therefrom'. This memoir marks an epoch in the history of physics. Before Clausius, truth and error were in a confusing state of mixture, and wrong answers were confidently urged by the highest authorities"

— Willard Gibbs (1889), 'Rudolf Clausius' (pg. 262)

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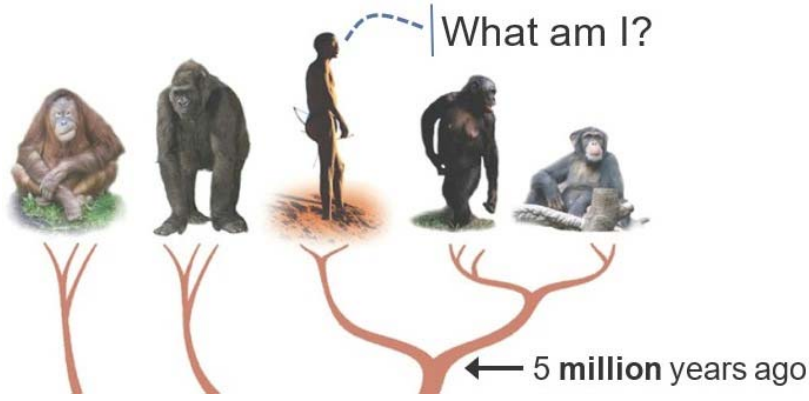
In the *table of contents*, chapters with key icons '🔑', right pointed: very key and or 'hard' key chapters or sections, or '🔑', left pointed: less key and or 'soft' key chapters or sections, are CORE chapters essential to the *derivation* of the fundamental equations of existence. The more keys, e.g. Clausius 🔑🔑🔑🔑, the more essential the material, and the more time and slowness of processing and digestion one should devote to the material.

1. What is a Human?

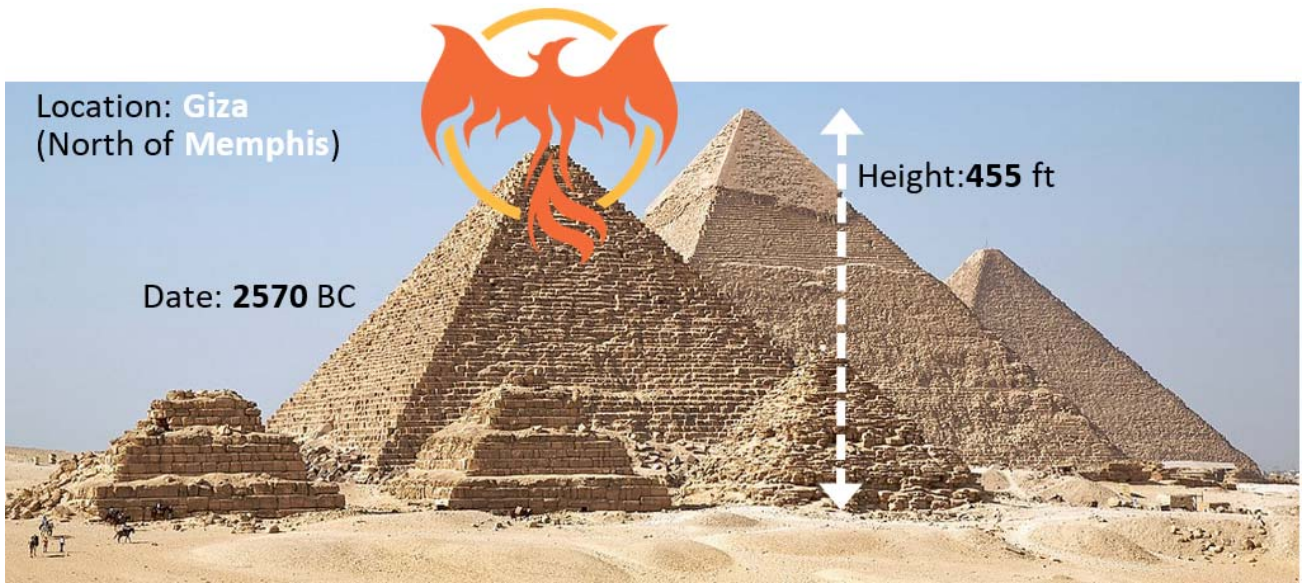
> "To a materialist no thing is real but *atoms* in a *void* and **we are but 'molecular people'** controlled by the actions of natural physicochemical law."
>
> — George Scott (1985), *Atoms of the Living Flame* (pg. 181)

Chapter point: define a 'human' according to chemical thermodynamics [length: 21-pgs].

The question 'what is a human?, 'what am I?', or what is a *person*, is quite possibly the oldest question known to so-called *human*-kind, or the bipedal 'animate' thing that diverged from apes, some five-million years ago, to become a new species that sexually reproduces with its own kind.

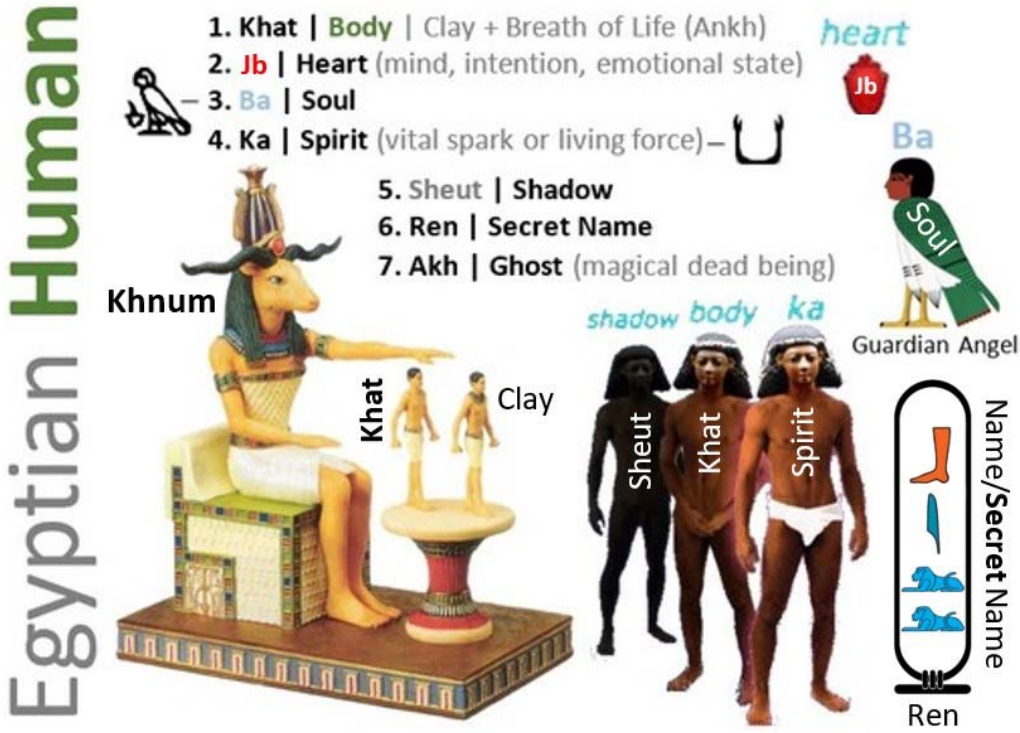


In 3,300BC, humans, in Egypt, had developed a symbolic notation system, which has been verified by radio-carbon dating, which employed rudimentary drawings of animals, plants, and mountains, along with records of linen and oil deliveries. In 2,500BC, in Memphis, Egypt, thinkers came to conceptualize the model that a 'human' was a clay thing, formed by one of the children of a phoenix-like son god, who was born out of the tip of a pyramid:



This sun god, over the centuries, was modified into various incarnate forms, namely: Ra, Ptah, Ogdoad, Amen, and Aten, etc., as the state religious center changed over time, from Heliopolis (3100BC), to Memphis (2800BC), to Hermopolis (2400BC), to Thebes (2050B), to Amarna (1300BC). As this model of this sun god changed over time, so, likewise, did the model of what a 'human' was, change over time.

The following, in overview, is the general model of the 'Egyptian human', derived from the summation of ideas produced by these previous five Egyptian religious centers, the gist of which being that a human was thought to be a clay-based type of matter, made by a god, e.g. Khnum, one of the children of the sun god, who made humans on his divine potters' wheel, each human having six additional attributes: a heart (Jb), a soul (Ba), a spirit (Ka), a shadow (Sheut), a secret name (Ren), and a ghost (Aka), in short, as summarized below:[7]



In c.850BC to 250BC, the Greek geniuses, specifically: Lycurgus (870BC), Orpheus (695BC), Solon (608BC), Thales (608BC), Pythagoras (540BC), Empedocles (465BC), Herodotus (454BC), Democritus (430BC), and Plato (397BC), thirsty for knowledge, all traveled to Egypt, to study abroad in their universities and religious schools, primarily at the colleges at Heliopolis and Memphis.

In 350BC, Aristotle, in his *Physics*, after studying all the ideas of all the Greek thinkers come before him, such as listed above, predominately: Plato, his teacher, Homer, Empedocles, Anaxagoras, Democritus, Pythagoras, Euripides, Socrates, and Heraclitus, in that order, respectively, as determined by the name index citation rankings of his collected works, came to define a human as either an *atomic thing*, Democritus' view, or a *four element thing*: water, earth, fire, air, which was Empedocles' view, although he tended to side more with the Empedoclean model.

All in all, Aristotle came to define a human as a theoretical *thing* or 'existent', as he referred to humans, as most thinkers back then were 'thing philosophers'.[14] This material based human *thing* or existent, according to Aristotle, also had an *animus* [mind] and *anima* [soul], which was the principle of its movement. He also stated that humans had a predisposed destiny, which he called a 'final cause', based on the argument that each thing, had a unique *matter-to-void ratio*, which directed, via his now-defunct *teleological* movement theory, the body to its final destination *place*, the way, in his mind, heat tends to rise, and rocks tend to fall. The shortened version of Aristotle's model of a human, is that he defined people as a type of existing thing that had motion:

> "A similar inquiry is made by those who inquire into the 'number of **existents**'; for they inquire whether the ultimate constitutes of **existing things** are one or many, and if many, whether a finite or an infinite plurality. So, they are inquiring whether the principle or element is one or many. We must take for granted that the things that exist by nature are, either all or some of them, in motion—which is made plain by induction."
>
> — Aristotle (350BC), *Physics* (§1)

After Aristotle, over the course of the next thirteen centuries, the above so-called **Aristotelian model** of a human, became the standard model for nearly the entire world. Presently, a good portion of the world still

believes this model, or a modified variation of it, particularly when it comes to beliefs in things such movement, soul, and or destiny.

When, however, the 'Aristotelian model' meets the 'chemical thermodynamics', i.e. the *thermodynamic* model of the universe, or rather the '*physico-chemical* model' of things, Aristotle loses. To give a quick example of where this collision, between these two models, impacts our modern belief systems, the following peculiar quote by Kurt Bell, an American atheistic philosopher, hits directly at the crux of the matter, in respect to our undisclosed reactionary Aristotelian predispositions:

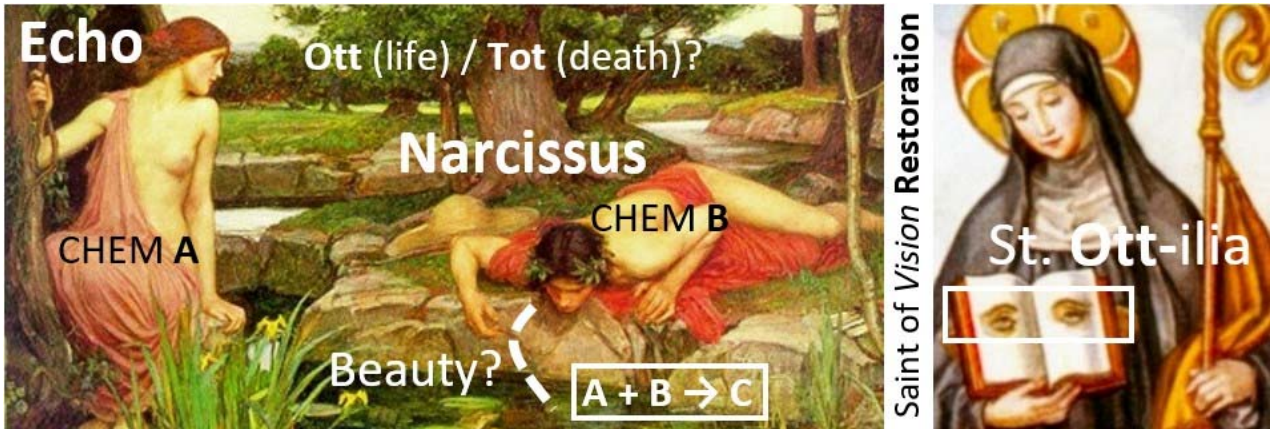
> "On my better days **I regard my wife and daughter as 'soulless bags of chemicals.'** To be fair though, I think the same of myself and all other forms of life. Souls are supernatural things beyond perception or measure, worthy only of suspended belief pending some real evidence or the giving up of the tenets of science. **Chemicals we are**, despite the clever animation of flesh and musings of mind brought about by the electricity of life. So why do we think more of ourselves? How are we so offended by these facts?"
>
> — Kurt Bell (2011), 'Soulless Bag of Chemicals', Sep 2

Here, the premise of calling one's wife and or daughter a 'soulless bag of chemicals', will likely, to many, seem to be an anathema or basic derogatory phrasing, indicating that someone does not have morals or a just belief system. The statement also implies that people, according to the Bell model of things, are worthless bags of meaningless chemicals? This is similar to Stephen Hawking (1995) referring to people as 'heated chemical scum'.[5] The term 'scum', as defined, by Merriam-Webster (2000), means a: 'low, vile, or worthless person or group of people'. Herein, we will employ 'neutral' terminology that holds for both humans and hydrogen.

In 1758, Carl Linnaeus, Swedish naturalist, in his 10th edition of his *System of Nature*, divided his previous 'three kingdoms' classification of nature, i.e. *mineral*, *plant*, *animal*, into a further so-called *binomial* four-part subdivision of: classes, orders, genera, and species, according to which a human, in his mind, was a thing that belonged to the genus 'homo', Latin for *man*, and the species 'homo sapiens', Latin for *wise man*.

1.1 | CHEM things

In 1809, Johann Goethe, a German poly-intellect, being greatly influenced by Linnaeus, Torbern Bergman, a Swedish chemist and student of Linnaeus, Shakespeare, and Spinoza, respectively, in his chemically-coded novel *Elective Affinities*, defined, via three different cyphers, namely: ECHO, OTTO, and CHEM, humans to be metamorphosized chemicals or 'CHEM-things', that have an Ovid-stylized ECHO narcissist complex, tending to see the universe anthropomorphically, i.e. in one's own image, as Narcissus, while in the company of Echo, famously fell in love with his own reflection, while looking in a pool of water:[1]



Lastly, humans, according to Goethe, are things that have an OTTO-cypher confusion, believing on one hand that they are 'living' chemicals, i.e. OTT-things, like the character Ottilie, the new young 'life' of the novel, yet on the other hand, derived from TOT-things, the term 'tot' being German for 'dead', a reference to the chemicals the characters experiment with, in the laboratory beakers, which are inherently neither 'alive' nor 'dead', a question Goethe put to dialogue, but rather only either inert, existive, and or reactive, depending, such as how we now define noble gas as being inert, per reason that all eight of its valence shell

electrons are filled and it is satisfied, so to say. All of this, more than deep dialogue, was frankly put-to-the-mind, in Goethe's now-overly famous *chapter four*, multiple film renditions of which now being available.

1.2 | Powered CHNOPS+ things

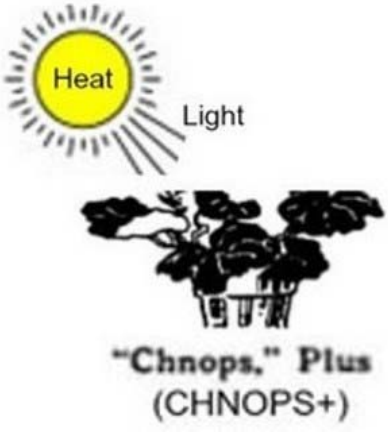
In 1926, William Ostwald, German physical chemist, auto-defined himself as a 'CHNOPS combination', as shown below, meaning that he knew that he was a combined thing made of six elements: carbon (C), hydrogen (H), nitrogen (N), oxygen (O), sulfur (S), and phosphorus (P):

> "I am made from the **C-H-N-O-S-P combination** from which a Bunsen, Helmholtz, Kirchhoff came."
> — Wilhelm Ostwald (1926), *Autobiography*

In 1936, Frank Thone, an American plant physiologist, in his *Science News Letters* article 'Nature Ramblings: Chnops, Plus', explained things to us as follows:

> "Six chemical elements are essential parts of protoplasm, the living substance itself. These are carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur. Their initial letters, which also happen to be their chemical symbols, have been arranged into a memory saving word or mnemonic: **CHNOPS**, pronounced like the German word for strong liquor, Schnapps."
> — Frank Thone (1936), 'Nature ramblings: Chnops, Plus' (pg. 110)

Thone, to illustrate this, depicted a heat-powered growing plant, captioned as a CHNOPS+ thing:[2]



The plus symbol ' + ', on Thone's initiative, will be employed herein, frequently, as a shorthand tool to say that a human, e.g., is a CHNOPS 'plus' twenty other elements thing, i.e. CHNOPS+20E thing, or a fish is a CHNOPS plus sixteen element thing or CHNOPS+16E thing, etc., in short.

In 1964, the term "CHNOPS system" was introduced by a group of researchers led George Armstrong, in their US National Bureau of Standards report 'Preliminary Report on Survey of Thermodynamic Properties of the Compounds of the Elements of CHNOPS', after which the term CHNOPS+ or CHNOPS system, became standard accepted terminology, for chemically defining plants and animals.

In 1974, Henry Swan, an American surgeon, noted for his thermodynamics-based hypothermia-induced heart stop technique for cardiac repair, in his *Thermoregulation and Bioenergetics*, via citation to Armstrong, described human, in a general way, as a 'powered' CHNOPS system or matrix. Specifically, in reference to hypothetical types so-called extraterrestrial 'life forms', Swan says the following:

> "A biochemistry could emerge [on other planets], in which **life is 'powered'** by the energizing of electrons by photons arriving from space, e.g. the rays of a star, with the local 'sink', i.e. final electron acceptor, being sulfur instead of oxygen. Such a [sulfur-based] life system would run on H_2S instead of H_2O, and in an entirely different temperature range. Its inhabitants would have no resemblance to life forms as we know them. Others, likewise, have suggested that liquid ammonia NH_3, instead of water, might serve as a solvent for biologic activity, per the reason that since ammonia boils at -33.4° C that this would permit [ammonia-based] life at temperatures well below the freezing point of water."
> — Henry Swan (1974), *Thermoregulation and Bioenergetics* (pgs. 2-3)

Here, barring digression on Swan's use of the now defunct term 'life', we will pause for a moment and try to focus in and absorb this notion of humans and plants as being a *powered* thing, or specifically powered CHNOPS+ systems or matrices.

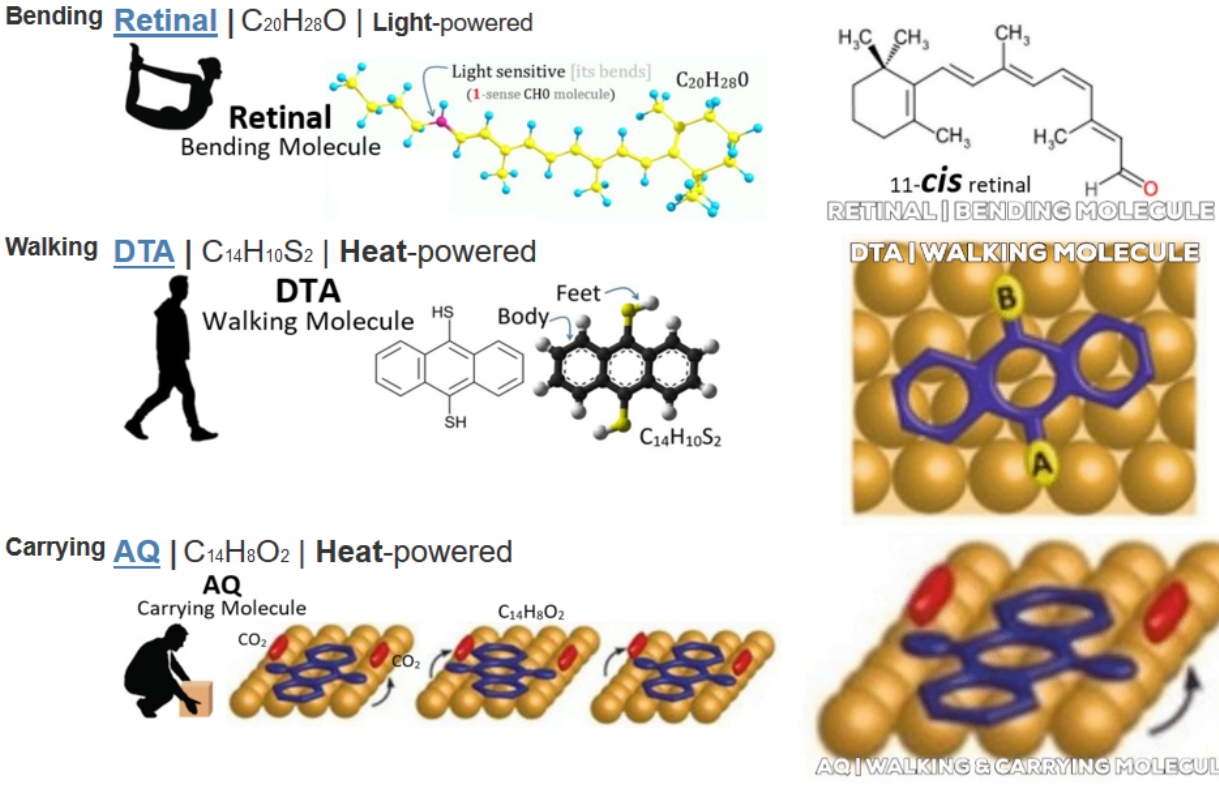
When the term 'powered' is inserted into the equation and verbal description, the term 'life' becomes superfluous, i.e. unnecessary. A human, thermodynamically speaking, in this Swan definitional sense of the matter, is a **powered** CHNOPS+ system (or matrix), and NOT a living CHNOPS+ system. This will be confusing, at first, for many. Just keep in mind that humans are derived from hydrogen atoms, and hydrogen atoms, by definition are NOT alive. The following quote should be kept in mind:

> "Hydrogen is a light, odorless gas, which, given enough time, turns into people."
> — Edward Harrison (c.1990), *Publication*

We will sidestep this involved topic for the moment, and leave it for an end chapter called 'Abioism'. The important point to keep in mind, at this point is that when chemical thermodynamically theorizing about yourself, society, economics, or what have you, it important to use the Swan terminology of 'powered CHNOPS+ system' instead the 'living CHNOPS+ system', per reason that physics, chemistry, and chemical thermodynamics in particular, as Charles Sherrington (1938) has pointed out, does NOT recognize the term 'life'.

This is a very important semantic point to keep in mind, particularly in the chemical thermodynamic study of human existence and origins. When, e.g., one tries to trace the concept of 'life' backwards in time, human to hydrogen, one runs into, at the scale of complexity of about the virus, a number of absurdities and convoluted chemical perpetual motion theories. If, alternatively, one carries the model of a human, animal, or plant, etc., being defined as a 'powered CHNOPS+ system', then there are no difficulties encountered in tracing the mechanism back into to the formation of the first hydrogen atom in the universe.

When, for example, to elaborate, in passing, we discover that there exists a 3-element molecule called retinal, in the back of the human eye, that animates via a light-powered mechanism, as shown below, we arrive at a decisive amount of anthropomorphically-ingrained confusion, about the nature of our own movement:[3]

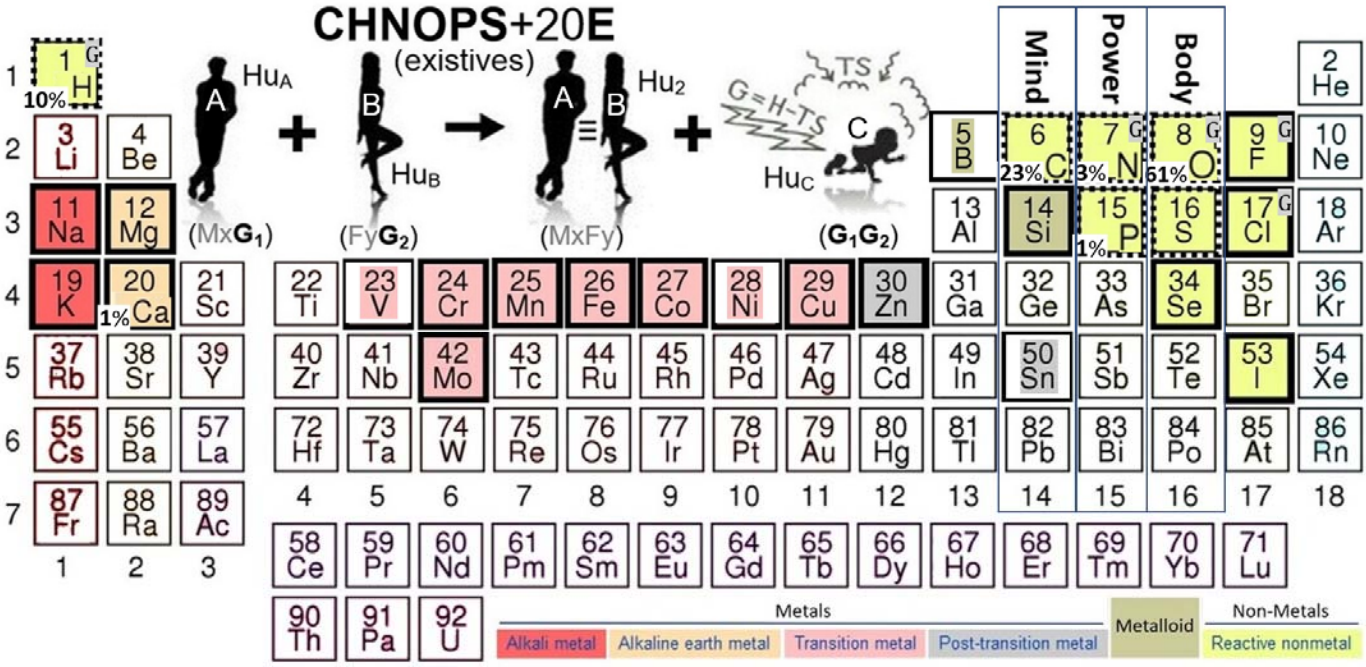


Likewise, when we learn that researchers can now make synthetic 'walking' molecules, in laboratories, such as DTA (Bartels, 2004), shown above, middle row, or AQ (Bartels, 2007), as shown above, bottom row, both being heat-*powered* types of animation, i.e. they only begin to walk, when on a copper surface, AND also heated, the notion of self-powering becomes defunct.

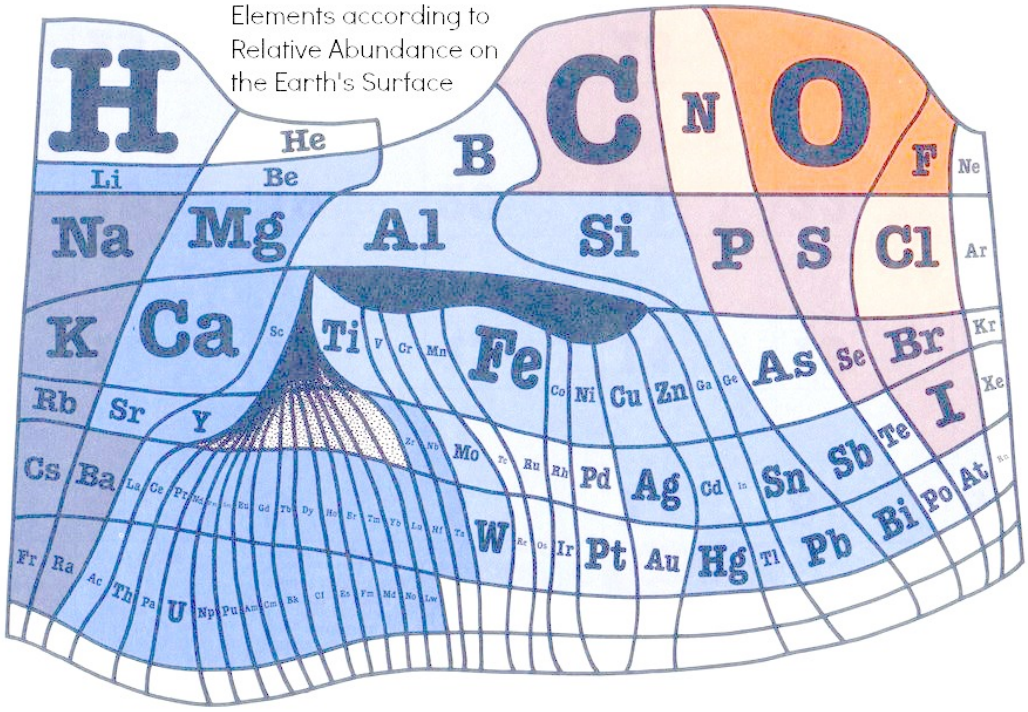
The reader is encouraged to go online to view the animated gifs of these three CH-based walking molecules, so to evidence to one's own minds eye, the importance of using the prefix 'powered' when describing humans or animals as being powered CHNOPS+ things.[3]

1.3 | Periodic Table

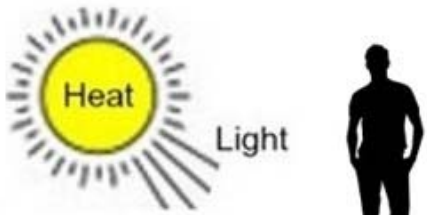
The following is a standard periodic table, albeit with all synthetically-made elements, numbers 93 (Np) to 118 (Og), removed, as these unstable elements do not naturally occur on earth, and therefore have no bearing in respect to the chemical thermodynamics of humans, thus showing, resultantly, the 26-elements, according to modern mass composition tables and physiology, that define a person, elemently and compositionally, hydrogen H, atomic 1 (H), or hydrogen, to atomic number 53 (I), or iodine, with mass composition percentages shown for the top six elements which comprise humans, by percent mass:



First, we note, when comparing our elemental composition, with the relative abundance of elements on the surface of the earth, as shown in the following so-called Sheehan periodic table (1970), we see that we are predominately things made of the skin of the earth, so to say, i.e. oxygen, carbon, hydrogen, nitrogen, phosphorus, calcium, mainly, based or comprised things:



Second, as we see, we are predominately a 'reactive nonmetal', as indicated by the yellow color-coding, of the elements: O, C, H, N, and P, which thus characterizes our so-called 'reactive nature', which quite obviously differentiates us from a say a typical 'rock', and its typical non-reactive nature, generally, like glauconite, molecular formula: (K, Na) (Fe, Al, Mg)$_2$ (Si, Al)$_4$ O$_{10}$ (OH)$_2$, shown below:[13]



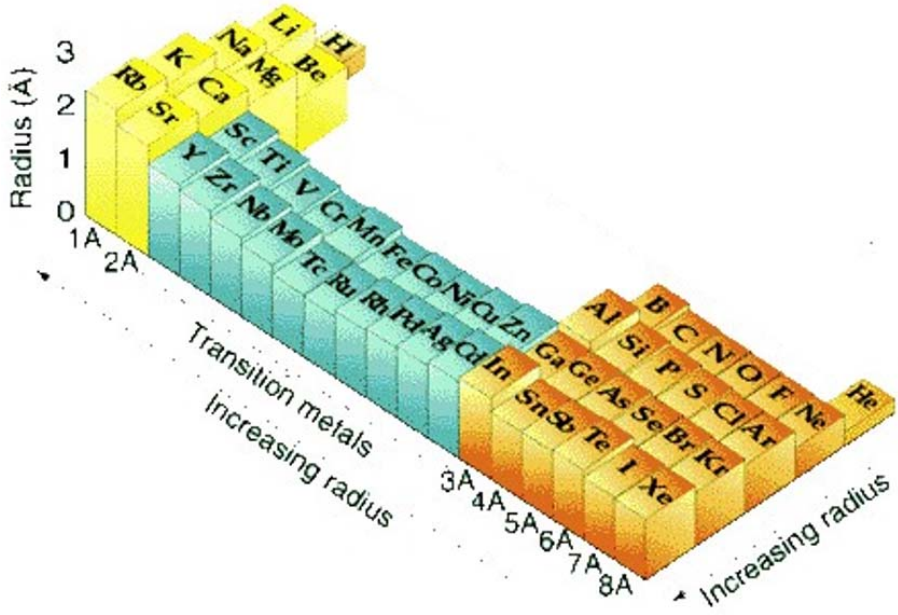
(K, Na) (Fe, **Al**, Mg)$_2$
(**Si**, Al)$_4$ O$_{10}$ (OH)$_2$

C$_{10^{27}}$ **H**$_{10^{27}}$ **O**$_{10^{27}}$ **N**$_{10^{26}}$ **P**$_{10^{25}}$ **S**$_{10^{24}}$ Ca$_{10^{25}}$
K$_{10^{24}}$ Cl$_{10^{24}}$ Na$_{10^{24}}$ Mg$_{10^{24}}$ Fe$_{10^{23}}$ F$_{10^{23}}$
Zn$_{10^{22}}$ Si$_{10^{22}}$ Cu$_{10^{21}}$ B$_{10^{21}}$ I$_{10^{20}}$ Sn$_{10^{20}}$ Mn$_{10^{20}}$
Se$_{10^{20}}$ Cr$_{10^{20}}$ Ni$_{10^{20}}$ Mo$_{10^{19}}$ Co$_{10^{19}}$ V$_{10^{18}}$

The rock vs human comparison, of note, in the history of philosophical debate, in all probability, is one of the most reoccurring *idiotic* yet very 'intelligent' comparisons, and a ripe, frequently reoccurring query, in human chemical thermodynamics, which is a strange peculiarity, to say the least

Third, we note that in respect to *mass*, the top six elements in humans are: O (61%), C (23%), H (10%), N (3%), Ca (1%), and P (1%), respectively; whereas, in respect to ranking actual *numbers* of elements in a human, the top six elements are: H (2.5E9), O (9.7E8), C (4.9E8), N (4.7E7), P (9E6), and Ca (6.9E6); which, as we have just learned, is noticeably different from the classical: **C, H, N, O, P, and S**, aka the 'CHNOPS model', pronounced 'Schnapps' (Thone, 1935) or 'Chin-ups' (Thims, 2005), of the historically presumed to be core six elements of a person.

This difference, generally, is a result of the size of some elements, e.g. calcium (Ca) the element in humans with the largest radius, as shown below, as compared to hydrogen (H), the element in humans with the smallest atomic radius, which differs from the distribution of elements by numbers rather than mass:



We will, however, continue to employ the classically ordering of: CHNOPS, for the first six main elements of humans, out of respect to historical modus operandi.[12]

Fourth, we note that columns 14, 15, and 16, are unique, in that the valance shell electrons of each column, periodically repeat, stepping upwards in each row, to make the properties of mind, power, and body, respectively, speaking in an anthropomorphic sense.

Column 14, is the so-called **'mind' column**, being that the predominate material basis of 'thinking' involves changes in the hydrocarbon bonds of the mind; the element carbon C, with its four-pronged bonding arrangement, which is where the feeling of 'choice' originates, being the row 2, column 14 element. This is similar to how silicon, Si, the row 3, column 14 element, being a semi-conductor, is used to make silicon chips, for the central process unit of computers, the 'brain' of laptops, so to say. Similarly, germanium (Ge), the row 4, column 14 element, was used in 1947 by John Bardeen and Walter Brattain, working under William Shockley, at Bell Labs, to make the first transistor, a device used to amplify or switch electronic signals, kind of like a neuro, and is also now being used for silicon chips.

Column 15, represents the **'power' column**, per reason, firstly, that most of our diet is a result of a process called 'nitrogen fixation', wherein nitrogen N_2 in the air is converted into ammonia NH_3 or related nitrogenous compounds in the soil, which acts as fertilizer for plants, nitrogen N being the row 2, column 15 element. Secondly, a large majority of the powering of the physiological reactions inside of a human, actuates by the cleavage of the three high energy phosphate bonds, of adenosine triphosphate (ATP), otherwise known as the 'energy currency', which pays, so to say, for various exergonic, i.e. energy absorbing, chemical processes, such as seen in the powering of muscle contraction, phosphorus being the row 3, column 15 element. Phosphate, has the formula PO_4^{3-}, which shows that the energy, or 'peculiar type of chemical energy', as Fritz Lipmann (1946) put it, released, from these powerful bonds, derives from valence shell electron nature of phosphorus. This is similar to how nitrogen, the element behind nitroglycerin, aka dynamite, which has the formula $C_3H_5N_3O_9$, has an explosive nature, defined by the following reaction:

$$4C_3H_5N_3O_9\ (s) \rightarrow 6N_2\ (g) + 12\ CO\ (g) + 10\ H_2O\ (g) + 7\ O_2\ (g)$$

During which the unstable nitroglycerin, when tapped on, which triggers a lowering of the activation energy barrier, results in an explosive transformation into the new product molecules, with strong stable bonds, seen in the molecules N_2 and O_2.

Column 16, containing the human composition elements, O, S, and Se, constitutes the so-called **'body' column** of the periodic table, as seen in the Sheehan periodic table (1970), per reason that a human is 61 percent by mass comprised of oxygen. The next two elements, by mass, being carbon, 23 percent, and hydrogen, 10 percent, and nitrogen 2.6 percent. So, in short, a human is predominately a 'oxygen thing'.

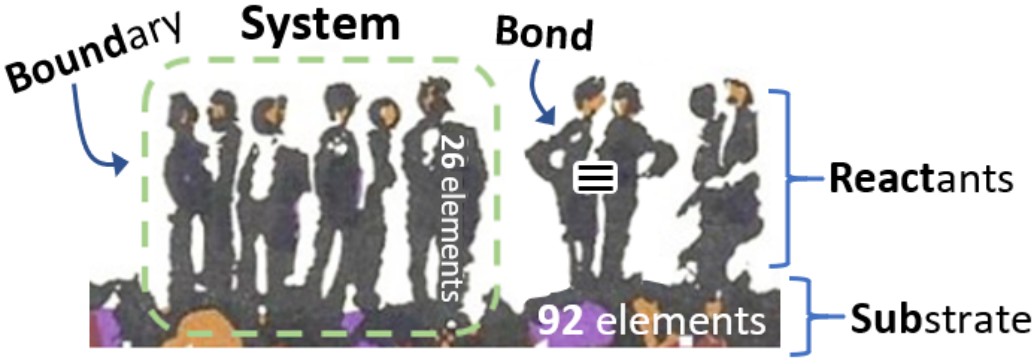
All of the row column patterns repeat, to note, per reason that elements are basically proton electron geometries, wherein the electrons arraign in spheres around the protons, kind of like Russian dolls, and the

properties of these dolls, e.g. mind, power, body, repeat, periodically, as ordered rows and columns in the periodic table.

1.4 | System and Boundary

Having now clearly established the so-called *elemental* definition of a human, wherein, to repeat: a human is a **powered 26-element thing**, in respect to the location of the elements of a human on a periodic table, which makes a person a 'unique' *bound state* atomic thing, say as compared to the other atomic 'things' that are made, on earth, from the total 92 natural elements, it now becomes a matter of default imperative to digress, in a preliminary manner, on the subject of the thermodynamic system **'boundary'**, which is the vessel, region, surface, or area of space, which encompasses the elemental thing we call 'human'.

The following, in this direction, shows the basic **'system'** model, in its simplest form, showing a region of space, delineated by the dotted line, or surface, which is called the 'boundary', which contain things inside of it which is called the 'working body', and where whatever is outside of the boundary of the system, is called the 'surroundings', the system here showing humans on a surface:



In this 'system' we see six humans. Outside the system, in the immediate surroundings, we see four humans, two of which are attached, via a chemical bond, signified by the triple bond symbol '≡'. The bond, as was discovered by Fritz Lipmann (1941), stores 'bond energy', which is an important component, as we will see when we get to the coupling chapter.

One important point or caveat to keep in mind, when choosing one's 'system' of study, is that the system must be large relative to molecular dimensions, i.e. relative to the dimensions of one human:

> "The first step is to define the system. A thermodynamic 'system' is simply that part of the universe in which we are interested. The only caveat is that **the system must be large relative to molecular dimensions**. Properties are either *extensive*, proportional to the mass of the system, or *intensive*, independent of mass."
>
> — Gordon Hammes (2000), *Thermodynamics and Kinetics for Biological Sciences* (pg. 2)

In the quote Hammes cited, the molecules or molecular 'things' in question are enzymes, such as ribonuclease, dihydrofolate reductase, chymotrypsin, which have the dimensions of several dozen angstroms. Humans, being the 'things' under study herein, have dimensions of meters. Simply put, one's system should generally be dimensioned so as to contain more than one human, more than hundred being ideal, but smaller dimension systems can be appropriate, where reality or necessity calls. There are the fields of single particle or single molecule thermodynamics, but these are advanced topics. The law of thermodynamics still apply to single molecule systems, to note, but in these system, which we will touch on, the function internal work of the molecules on each other does not exist, which is one of the components via which entropy change and entropy increase are defined; hence new formulations are required, and the topic becomes less real-world, like finding a single person on a deserted island.

The terms *extensive* and *intensive*, refers to variables or quantities of a system, that are proportional to the dimensions or mass of the system, and those that are not, respectively.

Below the ten humans, or ten powered CHNOPS+20E things, we see the *surface* of the earth, which is called 'substrate'. Humans, in a chemical reaction sense, technically are called 'reactants', which are the powered animate chemical 'things' that react on the substrate. Humans are comprised of 26 elements. The

substrate is comprised of 92 elements. There are many types of 'systems', and we will go through many examples.

The biggest conceptual problem we will face, is where to draw the boundary, in respect to which field of study we are working in, e.g. economics, sociology, ecology, history, or philosophy; the following is one frank statement of this so-called boundary problem:

> "**Boundaries** pose a problem for [energy-based] sociology."
> — Richard Adams (1988), *The Eight Day* (pg. 143)

Historically, to point out, great confusions, philosophically, as arisen by the idea that there are only three types of systems in thermodynamics, namely: 'open', 'closed', or 'isolated', and that if you know, in your great wisdom and mastery of thermodynamics, the correct 'type' of system, then you will know what entropy is doing, and therein state or proclaim some sort of proclamation about the future? While the tool of *prediction* does indeed exist within the framework of thermodynamics, the understanding of this is far more complex than picking A, B, or C. We will need to progress, however, through many chapters, before we can even begin to answer questions related to varieties of boundaries found in societies, thermodynamically speaking.

The first important point to make note of, is that the 'boundary', only includes the locations in which humans, or the 26 elements that comprise the *bound state* of a person, move, in a given system under study, in their daily, monthly, or yearly orbital movement patters. There is a top boundary, a bottom boundary, and many types of side boundaries.

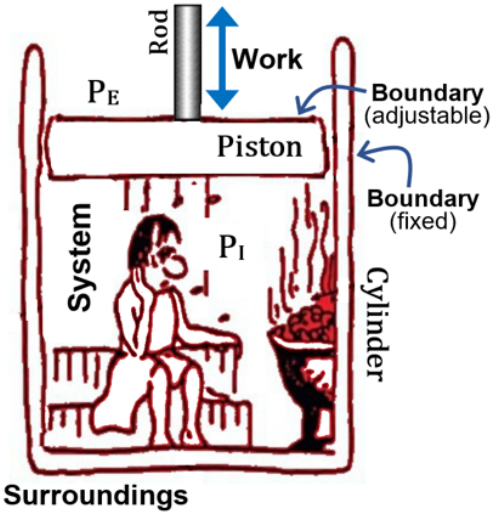
The **top boundary**, typically is the height of a given social system, e.g. the tallest building in a given town. Alternatively, if humans are flying, different 'systems' can be drawn, such as John Boyd (1960), a fighter pilot during the Korean War and engineer, theorized about, in the field of war thermodynamics, in terms of pilots, conceptualized as air molecules, battling each other in three-dimensional system in the sky, in order to formulated kill ratio models, in respect to air combat tactics.

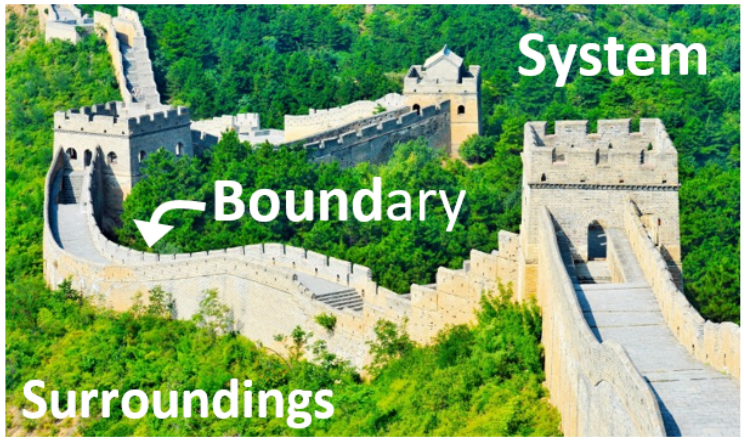
The **bottom boundary**, for the most part, for discussions of analysis, tends to be the line or region at the bottom of one's feet. The bottom boundary, in human chemical thermodynamics analysis, generally, does NOT extend several miles under the surface of the earth to include 'natural resources', like coal, gas, or oil. These are types of material elements that facilitate reactions between humans, but do not take part in the free energy reaction changes between humans. Certainly, to note, one can draw their 'boundary' in any location in the universe.

Generally speaking, however, chemical thermodynamics applied to humans will be concerned with *social boundaries*, i.e. protected or semi-protected barriers to where human are able to move, e.g. the Berlin Wall, the front door to a country club, the region around the 'alpha' table in the high school cafeteria.

In short, in the most basic definition of things, a completely *naked* 'human', with no attachments, clothes, food, jewelry, money, personal possessions, or other internal things, such as smuggled contraband in the anal cavity, e.g. heroin smuggled into prison, or swallowed contraband, e.g. diamonds kept secret during wartime, is a 26-element thing, plain and simple.

The **side boundary**, or side boundaries, however, are more complex. Below right, we see the Great Wall of China, built to protect China from its enemies and invaders from the North, especially the Mongols. The system, in this example, is China, the surroundings are the regions or territories outside of the wall. The wall is the boundary, which is semi-permeable, meaning that people can cross at guarded crossing points, or via stealth, scale the guard protected wall at great energetic risk and possible expense:





Above left, we see a 'man in piston and cylinder', a semi-famous illustration from German physicist Ingo Muller's 1994 *Essentials of Thermodynamics: with Historical Notes*, which shows a thinking man sitting next to a fire pit of burning wood or coals, who is being rained on by condensed steam, or something to this effect. The cylinder is the man's *fixed* social boundary, meaning un-moveable. The piston is the man's *adjustable* social boundary, meaning that he can push out on it, or the surroundings can push in on his system. The system, which is the space inside of the piston and cylinder, has an internal pressure P_I, representative of social pressure internal to the system. The surroundings, by contrast, has an external pressure P_E, representative of social pressure external to the system. The social piston, in short, will move, thus allowing for either work to be done *by the man* on the surroundings or, conversely, for the surroundings to do work *on the man*.

The surface, on which humans stand, or are 'attached', is called the *substrate*, and is comprised of 92-elements, give or take.

The surrounding gaseous atmosphere, in which this 26-element thing resides, is comprised of two elements, predominately, namely: nitrogen N_2 (78%) and oxygen O_2 (20.9%), along with residual amounts of six elemental things, namely: Ar (0.90%), CO_2 (0.03%), along with neon Ne, hydrogen H, helium He, and krypton Kr, comprising 0.17%, is classified as the reaction milieu. Just as some reactions will only take place in the water phase or *aqueous* phase, symbol 'aq', so to will human chemical reactions only actuate in the air phase, or the social milieu of an oxygen-based atmosphere.

We also are 'water' requiring reactionary things. The most basic model of this, was delineated when in 1775 Torbern Bergman, in his *Dissertation on Elective Attractions*, defined all reactions as being of two types: the 'wet way' (occurring in water) and the 'dry way' (occurring in air). Human social, sexual, political, and revolutionary 'reactions' actuate, in sum, amid a mixture of the wet way, e.g. large cities tend to be near water ports, and the dry way, in the atmosphere.

Things *not* part of a human, but which become 'part' of the existence of a person, such as a gold ring, a flower in a women's hair, shoes, clothes, a house, etc., are what are called *catalysts*, i.e. types of matter or material elements that lower ↓ the *activation energy barrier* of social reactions, but do not take part IN the social reactions themselves.

Things that a person consumes for metabolism, are defined as 'nutritive matter' or ***turnover* matter**, as discussed in a section to follow. Bacteria, e.g. will grow in *agar*, which is a gelatinous substance derived from red algae, which acts as the growth medium plus nutrients, for the bacteria. Humans, likewise, will grow in tropical region, but will not generally grow in a desert region, so much.

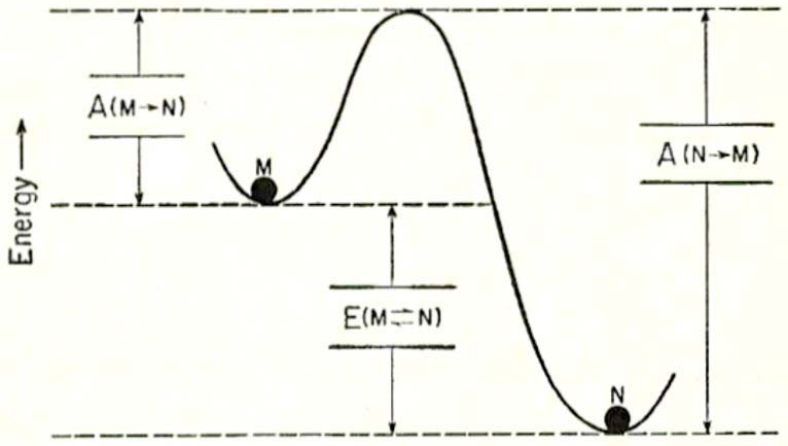
1.5 | Types of Matter and Reaction Energy

Boundary assignment, as we have said, is a complex subject. To touch on a quick example, one of the most-confused 'boundary assignment' examples, in recent years, is found in the fields of so-called 'entropy economics', centered around the work of Kenneth Boulding (1966), Nicholas Roegen (1971), and Herman Daly (1977), Roegen's PhD student, and physical 'ecological economics', centered around the work Howard Odum (1976) and Charles Hall (2011), Odum's PhD student. This will be digressed on more in the

Roegen-Samuelson Copper Economic Model chapter. Here, to get our feet wet to some real time, being practiced currently, working confusions, the gist of their total confusion resides in a basic lack of having boundary-defined system model and also how energy and or entropy related to ‘natural resources’, such as oil, coil, trees, copper, food crops, etc., are conceptually defined as per human chemical thermodynamics.

Boulding, e.g., attempting to defined natural recourses as ‘matter energy’; Roegen, thinking of coal and oil as ‘bound energy’ as waste gases as ‘free energy’; Daly employing terms such as ‘matter-energy’ and ‘entropy traps’; and Odum and Hall using electric circuit diagrams, as their thermodynamic system, thinking economic and ecological energy as like electric current flowing through ecological and economic systems; all of whom attempting to discuss these confused terminologies, in a grasping wan, in terms of the first two laws of thermodynamics. The problem here is that each of these persons are either economists or ecologists, nome of whom ever had any fundamental training in thermodynamics, let alone chemical thermodynamics.

To clarify, the following energy diagram, from Frederick Rossini’s *Chemical Thermodynamics* (1950), shows the correct way ‘energy’ is defined, specifically for two molecular entities, M and N, transforming, which in our scenario can be considered as two potential states of an economic system, embedded within an ecosystem:[15]



This diagram shows the energy of each system, on the vertical axis, showing the different states of potential energy existence of each system, the state’s energy reaction path shown by the curved line. Rossini explains the specifics of this diagram as follows:

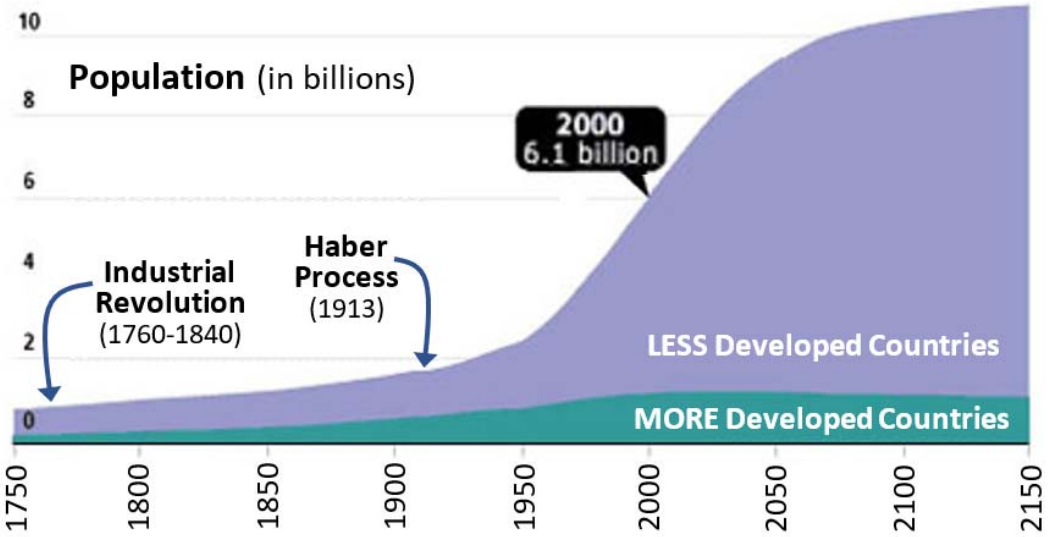
> “In the thermodynamic equilibrium, M ⇌ N, the initial and final states of the **atoms and molecules involved in the reaction** are represented by M and N, respectively. The state N is at a lower level of energy than the state M. The energy E (M ⇌ N) is the **energy of the reaction**, is related to the thermodynamic equilibrium, M ⇌ N, and, combined with the respective entropies, gives a complete description of the thermodynamic equilibrium. The energy A (M → N), is the energy of activation in the forward direction, M → N, and helps to determine the rate at which the molecules in the state M change to those in state N. The energy A (N → M), is the energy of activation in the reverse direction, N → M, and helps to determine the rate at which the molecules in state N change to those in state M. The difference in the energies of activation in the two directions is equal to the energy of reaction, E (M ⇌ N). By means of a **suitable catalyst**, the energy of activation can be materially reduced, producing a correspondingly large increase in the rate of reaction.”
>
> — Frederick Rossini (1950), *Chemical Thermodynamics* (pg. 3)

Here, the key words are bolded. In the transformation between two potential types of economic systems, M and N, the symbols M and N only represent the ‘atoms and molecules involved in the reaction’. In this case, it is the atoms and molecules of the humans in each potential economic system. The humans reacting between themselves will have a corresponding ‘energy of reaction’, symbolized by energy E (M ⇌ N), which combined with the ‘respective entropies’, gives a complete description of the thermodynamic equilibrium, in respect to the two states of M and N.

Now, in respect to where confusion abounds, the atoms and molecules of ‘natural resources’, which are connected to these forward and reverse reactions, such as coal, oil, gas, which power societies, or crops, which feed societies, or valuable metals, such as gold and platinum, which are used for tools, etc., are what

Rossini calls 'suitable catalysts', and their operational effect is on the raising or lowering of the two activation energies, A (M → N) and A (N → M), of either the forward and reverse reactions, depending.

Two examples from history clarify this. The first occurred when Fritz Haber figured out how to make ammonia NH_3, a key soil fertilizer for crop growth, from air nitrogen N_2 and oxygen O_2, and in 1913 began to produce ammonia on an industrial scale, after which the world's population exploded, as shown below, previous ammonia fertilizer, being made in limited amounts, predominantly coming from guano or bat droppings accumulated in caves in South America:

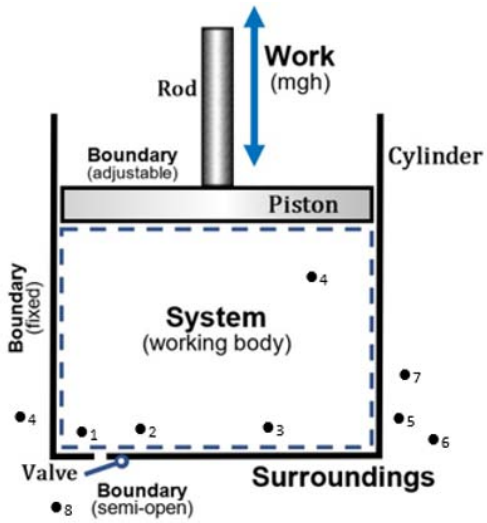


The second 'suitable catalytic' effect being the discovery of the steam engine, or method of transforming heat, in coal, into reciprocal motion, which resulted in the industrial revolution, and the economic and population growth derived therefrom; the key dates being 1732, when there were, supposedly, more than 100 Newcomen engines in Britain and Europe, and 2,000 Newcomen engines by 1800.

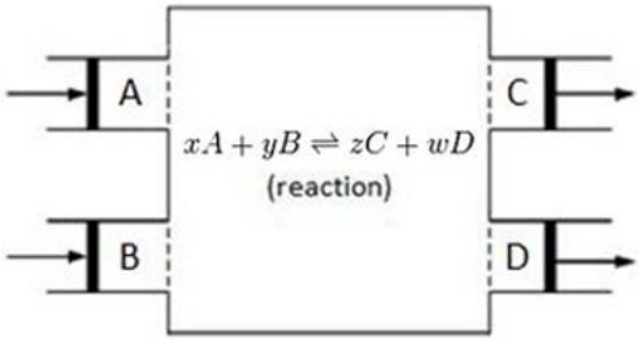
In each of these examples, namely the steam engine 'energy' and crop 'energy', were not economic reaction energies E (M ⇌ N), and the reaction entropies correlative therein, but rather they were related to the activation energies, A (M → N) and A (N → M), of the forward and reverse reaction, respectively. We will need to progress through many core chapters before we can elaborate more on this in detail.

The essential point to keep in mind, however, at this point is firstly that the human reaction system of study needs to conceptualized in terms of the 'piston and cylinder' reaction model, and secondly the matter inside of the system are divided into two categories, the first being: *reactive matter*, specifically humans, in our subject of study, and the remaining matter, which can generally be divided into three types, namely: and *substrate matter*, that which facilitates the reactions, e.g. the metal of the steam engines which facilitated the industrial revolution, *nutritive matter*, e.g. the ammonia derived from the Haber process, which facilitated the population explosion of the 20th century, and in chemistry is called the *system milieu matter*, e.g. does the reaction occur in the 'wet way', typically an aqueous reaction, or the dry way, occurring in an air environment.

To help conceptualized the idea of the 'system', in a thermodynamic definitional sense, the core model of which being the Clausius system (1865) reformulation of the Carnot engine (1824), which we will cover in detail later, the following two thermodynamic system models will be frequently employed as conceptual basic system models, appliable to social systems, namely the Da Vinci gunpowder engine, below left, and the Van't Hoff equilibrium reaction box model, below right:



Da Vinci
Gunpowder Engine Model
(1508)



Van't Hoff
Equilibrium Reaction Box Model
(1886)

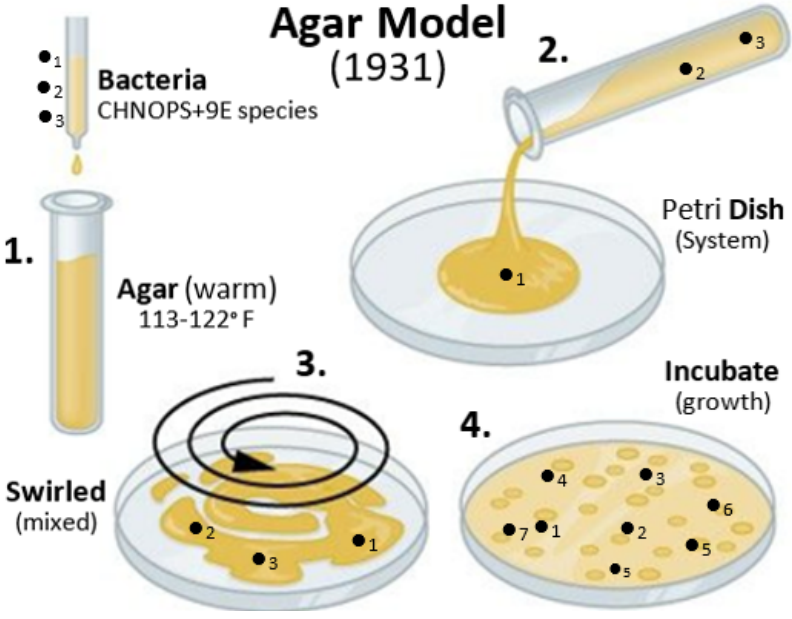
In the Da Vinci model, gunpowder explodes inside a piston and cylinder, the products, which are gases, and therein occupying greater volume, escape through a one-way out valve, this creates a partial vacuum in the system, which works to lift a weight. This could be, e.g., a country exploding in a civil war, where citizens are forced to flee their country, such as currently happening in Niger and the Boko Haram situation.

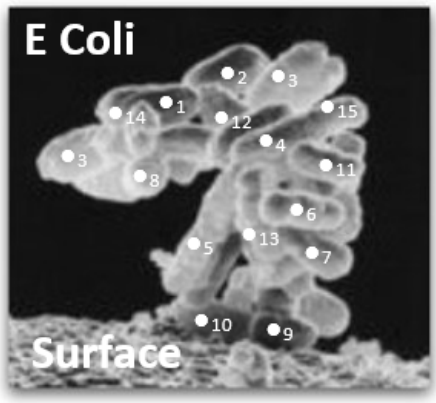
In the Van't Hoff model, two reactant and two product species, all in the gas phase, are connected to the reactive system, by four different semi-permeable membrane piston and cylinders, and we are able to gauge how much pressure-volume work each species does, at that entrance or exit point. This could be similar to the work involved when migrants, immigrants, or tourists, enter or leave a country.

At this point, many will be **over processed**, in their mind, as to what exactly the **'system'** is, as per modern thermodynamics. In an effort, to remedy this confusion, via a simple image, the following, sculpture, from the second story ledge of the Louvre Museum, Paris, which is the world's largest art museum, found aligned with statues of Descartes, Diderot, Voltaire, is the French engineer Denis Papin, shown holding a sectioned piston and cylinder, namely a cylinder, cut away to expose a piston and rod within it.

The region of space below the head of the piston, but above the bottom of the cylinder, is our social system, in its most basic form. Just let this work through your mind multiple times, for many years:

The following, a third conceptual system model we will employ, is the Agar Model, wherein the system is the petri dish, the bacteria are the reacting species, and the agar, which is a gelatin like material derived from red algae, is food + system milieu material, which allows the reacting species to grow, when heated:





$C_{E11}H_{E11}O_{E11}N_{E10}P_{E9}S_{E9}Ca_{E9}K_{E7}$
$Cl_{E7}Na_{E7}Mg_{E7}Fe_{E6}Si_{E5}Mn_{E3}Co_{E3}$

In the Da Vinci model, the 'system', in its most basic sense, is comprised of a cylinder, an *immovable* boundary, the piston, a *movable* boundary, a one-way out-going escape valve, which lets newly synthesized combustion products, i.e. gases made following combustion of gunpowder, *out* of the system, and a *working* substance, namely gunpowder, which is the equivalent of 'humans', in our case. The numbered particles shown being either gunpowder, humans, or bacteria (above right). In da Vinci's original draft model, the gun powder is 'ignited' inside the system. Think of a person being *ignited* by *falling in love* 'light'. This ignition, thereby causes the working body to explode, via chemical reaction.

The process of going from a solid phase to a gas phase results in a great increase in volume. Owing to this increase in volume, the products (gases) exit the piston and cylinder, through the escape valve. This results to make a partial 'vacuum' inside of the piston. This new change in state, results to make the 'forces' the molecules of the atmosphere, i.e. the weight of the atmosphere, to push down on the piston, i.e. do pressure-volume work *on* the system. Da Vinci, in order to utilize this newly made natural work, yielded by the powerful bonds stored in the gunpowder, connected the rod of his piston, via an inverted connecting mechanism, to a weight, which was thus lifted off the ground.

In the 'agar model', of bacterial growth, the walls of the petri dish make the boundary, which is fixed, the agar being the reaction milieu. This is one of the more basic comparison intermediate 'system' models, somewhere in between the da Vinci gunpowder model, and the more complex human social system. Here, the bacteria is a powered CHNOPS+9E thing, and is 'powered', via 'warming', namely the agar (food) is *heated* (think 'sun' at this point) to a temperature of 45 to 50° C (113-122° F), then mixed with the bacteria (think: human = 'evolved' bacteria), then spun (think rotating earth), left to *incubate* (think of the first 18-years of your existence), until the colonies (think: human *colonies* of early America) 'grow', i.e. sexually reproduce with other bacteria to form more bacteria.

The Van't Hoff model too complex in conceptual terminology to adequately summarized here, but we introduce it here, to show three levels of thermodynamic system modelling, namely simple combustion, gas phase reactions where boundary work is measured, and heated growth of CHNOPS+ things, as we progress our way up to the modelling of system of humans, which are heated, have explosive reactions, and do pressure boundary work and boundaries.

The point to note here, which has been confused up to the point of law-enforced US congressional legislation, is that gunpowder *reacts* with oxygen to make gas phase products, and bacteria *react* with other bacterial to make new colonies of bacteria. In the last model, which begins to become similar to human system models, the bacteria do not react WITH the agar, i.e. its food or substance milieu, which in chemistry is defined as the *catalyst* or *substrate* of the bacteria. Hence, humans, likewise, do not react with coal, carrots, or diamonds, but with each other, and this 'reaction energy' is the subject of focus.

Baring prolonged digression, which we will save for later chapters, the following quote, in respect to 'life' in general, will suffice to illustrated the general conclusion, as historically evidenced, that if one does not defined their *system* properly, they will, retrospectively, be shut down, in the future, in a not so pleasant manner, by someone of discerning intellect:

"It is *important* to **define the system**.

> When Schrodinger (*What is Life?*, 1943) is writing about a change in entropy of the system, **he NEVER even defines the 'system'.** Sometimes, he seems to consider that the system is a 'living organism' with no interaction whatever with the environment; and sometimes it is a living organism in thermal equilibrium with the environment; and sometimes it is the living organism **plu**s the environment, i.e. the universe as a whole."
>
> — Linus Pauling (1989), 'Schrodinger's Contribution to Chemistry and Biology'[8]

The important point, in conclusion of this subsection, is that if we are to arrive at a 'systematic conception of it all', as Henry Adams so-longed for, shown below, we must properly defined our system:

"I am quite READY to receive with *pleasure* ANY basis for a systematic conception of it all."

— Henry Adams (1864), 'Letter to Charles Gaskell', Oct

Then we need to properly first understand what a system is and then properly define our system.

1.6 | Turnover Rate

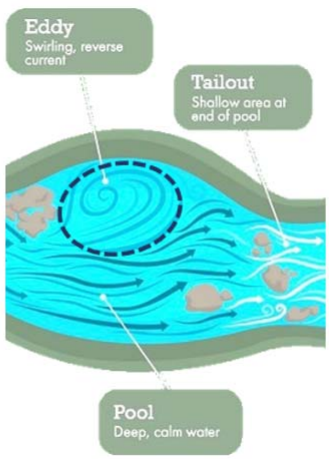
In 1938, Charles Sherrington, the English physiologist and neuroscientist, famous for introducing terms such as synapse and dendrite, the transmission connecting points of nerves, described humans, thermodynamically speaking, as being 'eddies' in the stream of energy of the universe, or swirling atomic structures in the thermodynamic arrow of time:

> "The 'living energy-system', in commerce with its surround, tends to increase itself. If we think of it as an **eddy in the stream of energy** it is an eddy which tends to grow; as part of this growth we have to reckon with its starting **other eddies** from its own resembling its own. This propensity it is which furnishes opportunity under the factors of evolution for a continual production of modified **patterns of eddy**. It is as though they progress toward something. But philosophy reflects that the motion for the eddy is in all cases drawn from the stream, and **the stream is destined**, so the second law of thermodynamics says, irrevocably to cease. The head driving it will, in accordance with the ascertained law of dynamics, run down. A state of static equilibrium will then replace the stream. And yet they will have been evolved. Their purpose then was temporary? It would seem so."
>
> — Charles Sherrington (1938), *Man on His Nature* (pg. 78)

Here, barring digression on Sherrington's 'running down' model of the second law, which we will correct in later chapters, here we see that, in his mind, a human is like the swirl pattern in a river, below left, having water molecules flowing through it, yet keeping its overall structure constant, or like afferent neuron, shown below right, which shows two 'excitatory afferents with their field of supraliminal effect in the moto-neuron pool of a muscle', the image being a commemorative stained glass window built in 1990, in the dining hall of Gonville and Caius College, Cambridge, in his honor:

"The people of Athens kept the '**ship of Theseus**' in good repair, **replacing its parts** as the decayed. Eventually, not a single original part of the ship is left. **Is it still the ship of Theseus?**"

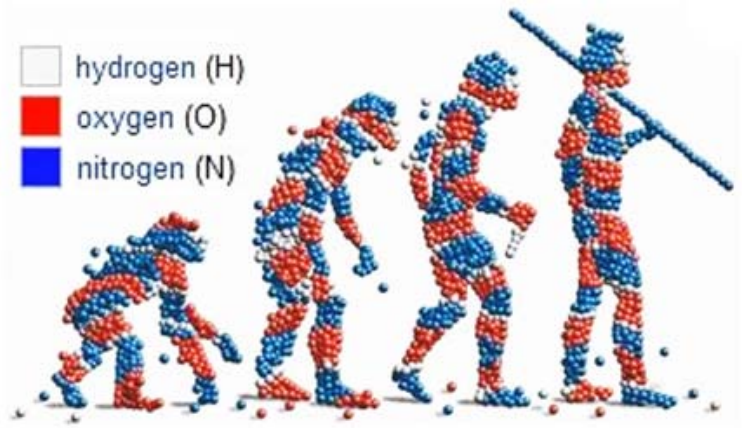
— **Cicero** (c.100), *Publication*

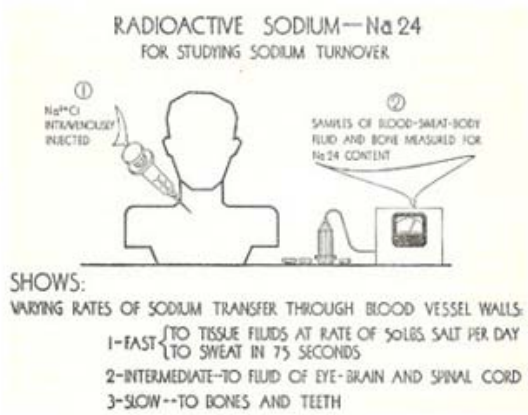


Above right, we see the famous 'Ship of Theseus' paradox, which goes back to Thales, the gist of which being that if you replace every part of ship or every atom of a human, which turnover rate implies, is it the same ship or human? The short answer is yes: the geometry of the electromagnetic field holds, while the atoms turnover.

In 1949, Paul Aebersold, an American physicist, as discussed in his 'Atomic Energy Benefits: Radioisotopes', had conducted a number of experiment at Oak Ridge National Laboratory, Tennessee, using

radioisotopes and the tracing of elements in and out of the human body, wherein he found that about 98 percent of the atoms in a person are 'turned over' and replaced with new atoms every two years, with the longest turnover rate of elements occurring in the teeth:





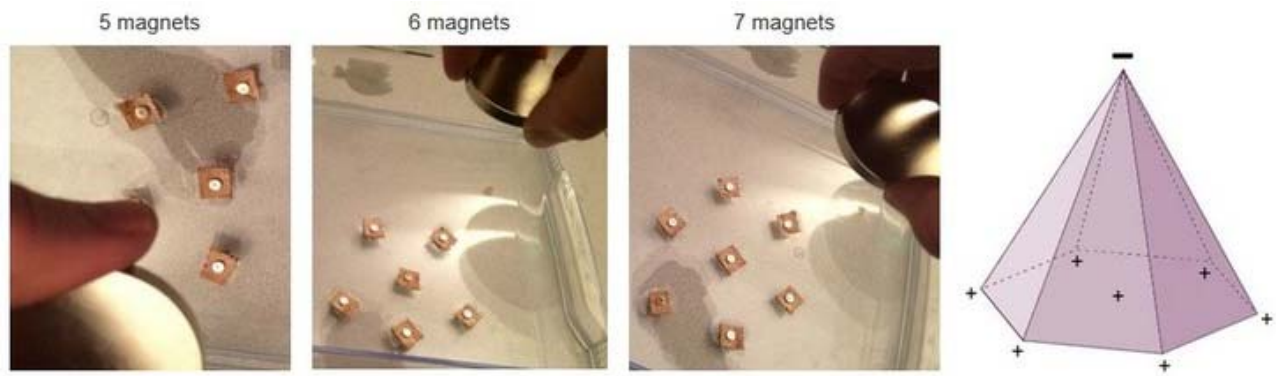
Aebersold described this atomic turnover as follows

> "The atoms now in your body are being replaced by new atoms at an amazingly rapid rate. Before we go into more detail about the terrific traffic of atoms in your body, or, for that matter, the **rapid atomic turnover** in all forms of life, in even the simplest organisms, let us pause for some background information that may forestall the quite justified unbelief you may have concerning these startling facts. How do we know all this? How do we follow all the fast and complicated maneuvers that atoms enter into in our bodies and other complex systems?"
>
> — Paul Aebersold (1949), 'Atomic Energy Benefits: Radioisotopes' (pg. #)

To help us conceptually understand the phenomena of *human atomic turnover*, we can, in some realistic sense, think of humans as geometric 'proton-electron configurations', or a 'locus in the electron-proton movement continuum', as Albert Weiss, American physicist and second generation student of Max Planck, defined things; for example:

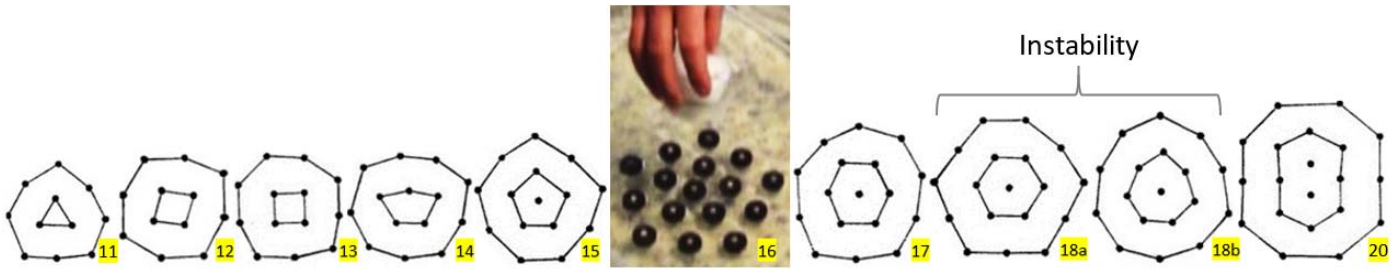
> "For purposes of description, each separate **geometrical electron-proton pattern**, no matter how simple or complex it may be, is to be regarded as a 'system'. Such systems may be classified into the degrees of the similarity or dissimilarity postulated of atoms, molecules, compounds, tissues, plants, animals, **men**, races, nations, planets, etc. The systems of especial interest to the behaviorist are classified under animal tissues and **social organizations**."
>
> — Albert Weiss (1925), *A Theoretical Basis of Human Behavior* (pg. 19)

With this definition in place, we will now cite the famous 'floating magnets' experiment, originally performed by William Gilbert (c.1590), with little floating cork boats, then expanded on by Alfred Mayer (1878) with up to about 20 magnets, the geometries found drawn by him, as shown below, then repeated by the author (2015), shown below, using more powerful neodymium magnets:



In short, Mayer and Gilbert found, that by placing little magnets on floating cork, with the positive pole facing upward, and placing a bigger magnet above them, with the negative pole facing downward, that three-dimensional magnetic geometries would form, like the hexagonal pyramid, shown above right. By

adding increasing numbers of smaller magnets, Gilbert and Mayer found the system arranging into large geometrical patterns, which at certain magnet count level, became unstable, e.g. at the 18-magnet level, wherein two alternative geometries would form, as shown below:



In short, by thinking of humans, in a simplified manner, as proton-electron configurations, the protons being like little floating positively charged particles, or positively oriented magnets, so to say, the electrons like little negatively charged particles or negatively oriented magnets, which interact to form three dimensional geometries, like a fish, ape, human, or hexagonal pyramid, we can understand how when a new atom or floating magnet is pushed or forced into the extant geometry, one atom or floating magnet, previously in the geometry, will be forced out, where, overtime, an atomic or magnetic turnover of material will accrue.

Here, just as with atoms in humans, certain geometries will be stable, based on the number of protons and electrons in a region of space, or large positive magnet in the vicinity of smaller floating negative magnets, as shown above. Hence, when the stable hexagonal pyramid forms, one can push in smaller magnets into the arrangement, during which, the electromagnetic force, will push out the old atoms or the destabilized magnets, but the overall pattern of the electromagnetic field, i.e. ship, hexagonal pyramid, or personhood, holds.

While this magnetic turnover model is not exactly the same as atomic turn, it does give a general conceptual idea of things. This model, in fact, was used in the discovery of the positive and negative geometric structure of the atom, by Joseph Thomson, in the derivation of his so-called plum pudding model. The following outline, gives a good idea of humans and societies as a system of positive and negative points, orchestrated via the tune of the gravitational and electromagnetic forces:

> "If we regard the chemical atom as an aggregation of a number of primordial atoms, the problem of finding the configurations of stable equilibrium for a number of equal particles acting on each other according to some law of force—whether that of Boscovich, where the **force between them is a repulsion when** they are separated by less than a certain critical distance, and **an attraction when they are separated by less than a certain critical distance**, and an attraction when they are separated by a greater distance, or even the simpler case of a number of mutually repellent particles held together by a central force—is of great interest in connexon with the relation between the properties of an element and its atomic weight. Unfortunately, the equations which determine the stability of such a collection of particles increase so rapidly in complexity with the number of particles that a general mathematical investigation is scarcely possible. We can, however, obtain **a good deal of insight** into the general **laws which govern such configurations** by the use of models, the simplest of which is the **floating magnets** of professor Mayer. In this model the magnets arrange themselves in equilibrium under the mutual repulsions and a central attraction caused by the pole of a large magnet placed above the floating magnets."
>
> — Joseph Thomson (1897), 'Cathode Rays' (pg. 293)

With this subsection on atomic turnover complete, we will quickly look at the *molecular formula model* or conception of a human.

1.7 | Molecular Formulas

In 2000, Robert Sterner and James Elser, two American limnologists, defined a 'human' according to the following 22-element *empirical* molecular formula:

$$\mathbf{H}_{375,000,000}\,\mathbf{O}_{132,000,000}\,\mathbf{C}_{85,700,000}\,\mathbf{N}_{6,430,000}\,\mathrm{Ca}_{1,500,000}\,\mathbf{P}_{1,020,000}\,\mathbf{S}_{206,000}\,\mathrm{Na}_{183,000}\,\mathrm{K}_{177,000}\,\mathrm{Cl}_{127,000}\,\mathrm{Mg}_{40,000}\,\mathrm{Si}_{38,600}\,\mathrm{Fe}_{2,680}\,\mathrm{Zn}_{2,110}\,\mathrm{Cu}_{76}\,\mathrm{I}_{14}\,\mathrm{Mn}_{13}\,\mathrm{F}_{13}\,\mathrm{Cr}_{7}\,\mathrm{Se}_{4}\,\mathrm{Mo}_{3}\,\mathrm{Co}$$

They stated, in passing commentary on this human *empirical* formula, that: 'this formula combines all compounds in a human being into a single **abstract 'molecule'**.' Here, supposedly, we have become an abstraction?

In 2002, the author, following several months of independent research, involving collations of data in respect to mass composition tables, surrounding the question of what defines a person at the second of 'death' or 'cessation of existence' (Jefferson, 1775), in the eyes of the first law of thermodynamics, a repercussion of an idea that arose amid drafting a chapter on death, for his unpublished *Human Thermodynamics* manuscript, research done independent of Sterner and Elser, calculated the following 26-element molecular formula for an average human :

$$\mathbf{C}_{10}^{27}\,\mathbf{H}_{10}^{27}\,\mathbf{N}_{10}^{26}\,\mathbf{O}_{10}^{27}\,\mathbf{P}_{10}^{25}\,\mathbf{S}_{10}^{24}$$

$$\mathrm{Ca}_{10}^{25}\,\mathrm{K}_{10}^{24}\,\mathrm{Cl}_{10}^{24}\,\mathrm{Na}_{10}^{24}\,\mathrm{Mg}_{10}^{24}\,\mathrm{Fe}_{10}^{23}\,\mathrm{F}_{10}^{23}\,\mathrm{Zn}_{10}^{22}\,\mathrm{Si}_{10}^{22}$$

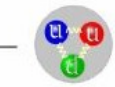
$$\mathrm{Cu}_{10}^{21}\,\mathbf{B}_{10}^{21}\,\mathrm{I}_{10}^{20}\,\mathbf{Sn}_{10}^{20}\,\mathrm{Mn}_{10}^{20}\,\mathrm{Se}_{10}^{20}\,\mathrm{Cr}_{10}^{20}\,\mathbf{Ni}_{10}^{20}\,\mathrm{Mo}_{10}^{19}\,\mathrm{Co}_{10}^{19}\,\mathbf{V}_{10}^{18}$$

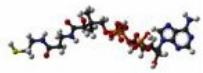
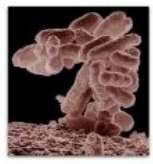
Following this, in the decades to follow, the author began to define a human as a 'molecule', as had been done by Jean Sales in 1789. Some, of note, objected to this terminological usage. In comparing these two formulas, the Sterner-Elser human molecular formula (2000) with the Thims human molecular formula (2002), we note that four elements, namely: B, V, Ni, and Mo, shown in italics in the above formula, are not seen in the Sterner-Elser formula, whereas they are shown in the Thims formula. This is a result of better research and formulation. The significance of these four additional elements is indicated by the added white boarders of these four elements in the so-called hmolscience periodic table, shown previously.

1.8 | Molecular Evolution Table

In 2005, Thims, following his calculation human formula, empirical and molecular, then began to calculate the molecular formulas of a number of things, smaller than humans, going backwards in the standard model evolution-based chain of beings, human to monkey, to reptile, to fish, to aquatic worm, to bacteria, and to smaller scales, e.g. DNA, urea, water, hydrogen, down to subatomic particles, constructed the following so-called molecular evolution table, which was published first online (2005), then in the chapter 'Molecular Evolution' of the author's two-volume 2007 *Human Chemistry* book, which was the reproduced, with some elaboration, in the author's 2008 *The Human Molecule* booklet, on the history of thinkers to have conceptualized a person as a molecule:[4]

Element Count	Molecular Evolution Table	Name	Date
N/A	*Fermions:* e^-, ν_e, u, d, μ^-, ν_μ, c, s, τ^-, ν_τ, t, b *Gauge bosons:* g_{ab}, γ, W^+, W^-, Z^0, G	Elementary Particles	13.7 BYA
1	H, He-3, He-4, Li	Atoms	3E5 YAB
1	H_2	Hydrogen	
2	H_2O	Water	2E8 YAB
3	CH_4O	Methanol	
4	CH_4ON_2	Urea	4.6 BYA
5	$C_{10}H_{16}O_{13}N_5P_3$	DNA	
6	$C_{21}H_{36}O_{16}N_7P_3S$	Coenzyme A	
7	$C_4H_3O_2NS_2NaI$	mol-7	4.4 BYA
8	$C_{20}H_{22}O_7N_2SNaIPt$	mol-8	
9			
10	$C_{E5}H_{E5}O_{E4}N_{E4}P_{E2}S_{E2}Ca_{E2}K_{E2}Cl_{E2}Na_{E2}$	Intermediate	4.2 BYA
11			
12	$C_{E7}H_{E7}O_{E6}N_{E6}P_{E4}S_{E4}Ca_{E4}K_{E3}Cl_{E3}Na_{E3}Mg_{E2}Fe_{E2}$	Pro-bacteria	4.0 BYA
13			
14			
15	$C_{E10}H_{E10}O_{E10}N_{E9}P_{E8}S_{E8}Ca_{E8}K_{E6}Cl_{E6}Na_{E6}Mg_{E6}Fe_{E5}$ $Si_{E4}Mn_{E2}Co_{E2}$	Prokaryote (Bacteria)	3.85 BYA
16			
17			
18	$C_{E16}H_{E16}O_{E16}N_{E15}P_{E14}S_{E14}Ca_{E14}K_{E12}Cl_{E12}Na_{E12}Mg_{E12}Fe_{E11}Fe_{E11}$ $Si_{E10}Cu_{E9}Mn_{E8}Se_{E8}Co_{E7}$	Pre-Aquatic Worm	2.6 BYA
19			
20			
21			
22	$C_{E22}H_{E22}O_{E22}N_{E21}P_{E20}S_{E19}Ca_{E20}K_{E18}Cl_{E18}Na_{E18}Mg_{E18}Fe_{E17}Fe_{E17}$ $Zn_{E16}Si_{E16}Cu_{E15}I_{E14}Mn_{E14}Se_{E14}Mo_{E13}Co_{E13}V_{E12}$	Fish	0.7 BYA
23		Reptile	350 MYA
24	$C_{E26}H_{E26}O_{E26}N_{E25}P_{E24}S_{E23}Ca_{E24}K_{E22}Cl_{E22}Na_{E22}Mg_{E22}Fe_{E21}Fe_{E21}$ $Zn_{E20}Si_{E20}Cu_{E19}Be_{E19}I_{E18}Mn_{E18}Se_{E18}Cr_{E18}Mo_{E17}Co_{E17}V_{E16}$	Old World Monkey	30 MYA
25		*A. Afarensis*	5.0 MYA
26	$C_{E27}H_{E27}O_{E27}N_{E26}P_{E25}S_{E24}Ca_{E25}K_{E24}Cl_{E24}Na_{E24}Mg_{E24}Fe_{E23}Fe_{E23}$ $Zn_{E22}Si_{E22}Cu_{E21}Be_{E21}I_{E20}Sn_{E20}Mn_{E20}Se_{E20}Cr_{E20}Ni_{E20}Mo_{E19}Co_{E19}V_{E18}$	Human (*H. Sapiens*)	0.2 MYA
27			
28		Evolution	



Here we see an expanded version of the 'abstract' of this book. Each row shows a characteristic H+, CH+, CHO+, CHNO+, CHNOPS+, etc., thing. Each of these things, when heated by the sun, chemically reacts to form either new product species, of the same nature, or new species. In order for any of these chemical reactions to proceed, a *decrease* in the free energy, for each reaction, must actuate. The measure of the free energy, or isothermal-isobaric chemical potential, is defined by symbol G, and is the result of a summation of the first and second law of thermodynamics. Notice, very clearly, how in all of this, hydrogen to human, rows one to twenty-six, we did NOT say anything about order form disorder.

Barring prolonged discussion, at this point, which will be clarified as we progress, the following statement, from American neurosurgeon Ben Carson, the first person to successful separate conjoined at the head Siamese twins, turned 2015 presidential candidate, gives a general idea of how the average person,

ignorant of basic human chemical thermodynamics, understands things, when it comes to questions that surround faith and science:

> "And you know, I get a lot of grief out there. People say, 'How can you be a scientist and believe that god created the earth? Obviously, you know [they say] **we developed from a puddle of promiscuous biochemicals**. And if you believe in anything other than that, you're a moron.' I don't criticize them. I say, 'Can you tell me how something came from nothing?' And, of course, they can't. They say 'well, we don't understand everything.' I say 'ok, no problem'. 'I'm just going to give you that there's something'. And now you're going to tell me there's a big bang, and it comes into perfect order? So that we can predict seventy-years hence when a comet is coming, that kind of precision. And they say, 'Well, yeah.' And I say, 'But **don't you also believe in entropy**, that things move toward a state of disorganization?' [they say] 'Well yah'. [I say] 'So **how does that work?** "And they say, 'We don't understand everything.' And I said 'I'm not sure you understand anything! ' But, I said, 'I'm not going to be critical of you, not a problem. You're entitled to believe what you believe, even though it requires a lot more faith than what I believe. But everybody believe what you want to believe."
>
> — Ben Carson (2015), 'Campaign Speech', Liberty University, Nov 11

Here, Carson, while being direct, thus opening up refreshing new Roegen avenues, is employing anthropomorphic pejoratives, which is not the correct way to go about chemical thermodynamics applied to the humanities, which employs an unbiased objective approach.

1.9 | Working Definition

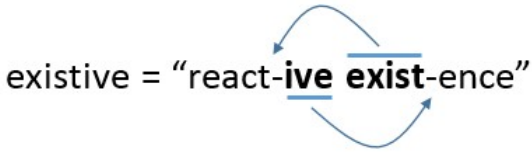
In respect to working definitions, we will note that in 2011, American thermodynamicist Kalyan Annamalai, in his *Advanced Thermodynamics Engineering*, per citation of the author, defined a human as a '26-element energy and or heat driven dynamic atomic structure'. This is in the neighborhood of the presently suggested term of 'powered CHNOPS+20 element' structure, matrix, system, chemical, molecule, existent, or thing.

Historically, the online Hmolpedia 'human' article, in tabulated chronological format, lists the top 130+ terms employed, over the last several centuries, to defined a *human*, from the physical, chemical, and or thermodynamical point of view. The more interesting terms, some of which we have touched on, are: '**tormented atoms**' (Voltaire, 1755), 'cogged dice matter machines' (Holbach, 1770), 'molecule' (Sales, 1789), 'animate combination of the universe' (Shelley, 1815), '**metamorphosized CHEM**' (Goethe, 1809), 'carbon gorgon' (Haeckel, 1888), 'phase' (Adams, 1908), '**electron-proton configuration**' (Weiss, 1925), '**CHNOPS plus**' thing (Thone, 1936), 'energy eddy' (Sherrington, 1938), 'dissipative structure' (Prigogine, 1972), '**powered CHNOPS** system or matrix' (Swan, 1974), 'fermion or boson' (Stephan, 1977), 'star stuff' (Sagan, 1980), 'electron spin' (Montroll, 1981), 'carbon-based biped' (Clarke, 1992), '**heated** chemical scum' (Hawking, 1995), 'baryonic matter' (Robinson, 1999), '**soulless** bag of chemicals' (Bell, 2011), and of course the last and more to the point '**promiscuous biochemical**' (Carson, 2015).[5]

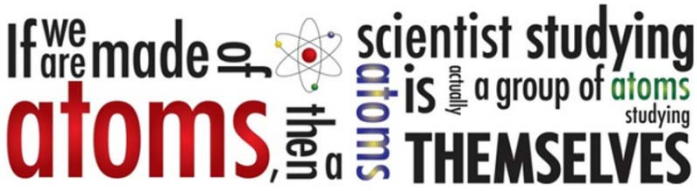
All of these, some bolded above to signify focus, Voltaire and Carson, aside, lack the basic components of 'emotion' and desire. Herein, per citation to David Buss' 1994 *The Evolution of Desire*, the anchor book of the science of *evolutionary psychology*, we will assume, as a standing matter of fact, that *desire*, however this term gets reformulated in the future, be it in the context of force, work, power, or energy, exists, and has evolved or transformed, as an exactly-defined thing or process, hydrogen to human, big bang up to the present day of this publication. Technically, however, one cannot say that hydrogen 'desires' oxygen, so to form water; this is but an example of terminology reform. First, however, we must register our working definition of a human: a power, as follows:

Human: *powered* CHNOPS+20 element existive

In this definition, to summarize and clarify, the terms: 'CHNOPS combination' (Ostwald, 1926), 'CHNOP+' notation (Thone, 1936), 'powered' (Swan, 1974), the number '20', being the difference of 26 minus 6, meaning the six CHNOPS elements, the number 26 being total number of elements in a human, per the Thims human molecular formula (2002), plus the clarifier 'existive', which is defined as follows:[6]



a combination of the Aristotelian-themed model of people defined as 'existing things' and or 'existents', which was modified, by the author (c.2103), into the new term 'existive', a conjunction of *reactive* + *existence*, as an upgrade to the now-classified defunct term 'alive' (Sherrington, 1938). The adjacent word scramble, to put this chapter into laughable perspective, is 2013 Yahoo Answers query, turned 2014 quote meme, which says that: if 'we are made of atoms', which is true, then a 'scientist', say you or I, studying atoms, is actually a 'group of atoms' studying themselves, which is a rather accurate synopsis of *things*, as Aristotle might say.



Synopsis: (add)

References

1. (a) http://www.eoht.info/page/CHEM+cypher
(b) http://www.eoht.info/page/ECHO
(c) http://www.eoht.info/page/OTTO
2. http://www.eoht.info/page/CHNOPS%2B
3. http://www.eoht.info/page/animate+thing
4. http://www.eoht.info/page/molecular+evolution+table
5. http://www.eoht.info/page/human
6. http://www.eoht.info/page/existive
7. http://www.eoht.info/page/Egyptian+human
8. http://www.eoht.info/page/Note+to+Chapter+6
9. http://www.eoht.info/page/Aristotle+citation+rankings
10. http://www.eoht.info/page/element
11. http://www.eoht.info/page/Boundary+problem
12. http://www.eoht.info/page/CHNOPS
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16.

Unlearn

"Fables should be taught as fables, myths as myths, and miracles as poetic fancies. To teach superstitions as truth is a most terrible thing. The **child mind accepts and believes them**, and only through great pain and perhaps tragedy can he or she be in after years relieved of them. The reason for this is that a superstition is so intangible a thing that you cannot get at it to refute it."

— Hypatia (400), *Publication* (pg. #)

The following handful of five or so chapters, on 'gods, Greeks, and the dark ages', are a slow, but necessary prerequisite, prior to the engagement of the chemical thermodynamics of humans. In the original Egyptian conception of things, heat was believed to be a god. Much of this ideology, was transmitted and carried forward into Greek science, in rescripted format. Much of this Greek science ideology, was transmitted and carried forward to us, not necessarily in our modern science, as objections about so-called Aristotelian science, as it was called, began to be raised in the 16th century, and thereafter reformed. These reformations, however, only actuated in the area of physics and chemistry of so-called *inanimate things*. No such reformation as actuated in the area of so-called *animate things*. No amount of trivial hand-waiving will erase this deeply ingrained, culturally and mentally, dichotomy.

That the 'child mind' believes and accepts that 'heat is a god', we will not attempt to address, nor argue at this point. We will acknowledge that this belief, covertly, is more than prevalent, worldwide. It will be up to the mind of the read to *unlearn* much of this ideology, if one is to fully understand *chemical thermodynamics*, either as a standalone subject, or applied to humans. We will not attempt to say much more on this topic, per reason that some of these 'unlearns' might require a decade, e.g. abioism, or more than half one's existence, as Gerald Massey frankly put things:

"Fables should be taught as fables, myths as myths, and miracles as poetic fancies. To teach superstitions as truth is a most terrible thing. The child mind accepts and believes them, and only through great pain and perhaps tragedy can he or she be in after years **relieved of them**. The reason for this is that a superstition is so intangible a thing that you cannot get at it to refute it."

— Hypatia (c.400), *Publication* (pg. #)

"You must acquire the best knowledge first, and without delay; it is the height of madness to learn what you will later have to **unlearn**."

— Desiderius Erasmus (1497), 'Letter to Christiaan Northoff'

"It is now some years since I detected how many were the **false beliefs** that I had from my earliest youth admitted as true and how doubtful was everything I had since constructed on this basis."

— Rene Descartes (date), *Medications on the First Philosophy* (pg. #)

"It hath often seemed to me beyond an ordinary probability, and something more than fancy, however paradoxical the conjecture may seem, to think that the least bodies we are able to see with our naked eyes, are but middle proportionals (as it were) betwixt the greatest and smallest bodies in nature, which two extremes lye equally beyond the reach of human sensation: for as on the one side they are but narrow souls, and not worthy the name of philosophers, that think any 'body' can be too great or too vast in its dimensions; so likewise are they as inapprehensive, and of the same litter as the former, that on the other side think the particles of matter may be too little, and that nature is stinted at an 'atom', and must have a non-ultra of her subdivisions. Such, I am sure, our modern engine (the micro-scope) will ocularly evince and **unlearn them their opinions** again: for herein you may see what a subtill divider of matter nature is."

— Henry Power (1664), *Publication* (pg. #)

"The latter part of a wise man's life is taken up in **curing the follies, prejudices, and false opinions** he had contracted in the former."

— Jonathan Swift (1706), 'Thoughts on Various Subjects, Moral and Diverting'

> "The shortest and surest way of arriving at real knowledge is to unlearn the lessons we have been taught, to mount the first principles, and take nobody's word about them."
>
> — Lord Bolingbroke (c.1730), *Publication* (pg. #)

> "I remember well the enthusiasm with which I devoured Hume when young, and the length of time, the research and reflection which were necessary **to eradicate** the poison it had instilled into my mind."
>
> — Thomas Jefferson (1810), 'Letter to William Duane', Aug 12

> "Almost all of the latter part of my life has been spent **unlearning the nonsense** I learned in my youth."
>
> — Godfrey Higgins (1833), *Anacalypsis, Volume One* (pg. x); cited by Tom Harpur (2004) in The Pagan Christ (pg. 200)

> "It takes the latter half of all of one's lifetime to **unlearn the falsehood** that was instilled into us during the earlier half. Generation after generation we learn, unlearn, and re-learn the same lying legendary lore. Henceforth, our studies must begin from the evolutionist standpoint in order that they may not have to be gone over again."
>
> — Gerald Massey (1883), *The Natural Genesis, Volume One* (pg. 2)

> "Beware of **false knowledge**; it is more dangerous than ignorance."
>
> — Bernard Shaw (c.1920), *Publication* (pg. #)

> "Pareto's Treatise on General Sociology is the hardest boiled book I have ever read. Three times, since I passed my puberty, has my mind been made over. Once by a nexus of which Henry Adams was the center, once by a matrix of which Frazer burned brightest, and once by a long study of genetics and evolution. Pareto is doing the job a fourth time, and far more vitally than any others."
>
> — Bernard DeVoto (1928), commentary on Pareto's *Treatise on General Sociology* (pg. #)

In order to formidably proceed past this point, one must be willing to potentially 'unlearn' many of the mental errors, he or she was instructed upon, in youth, and or culturally ingrained with. The *new* belief system we will be learning herein, based on reproducible, and time-tested experimental observation, aka *experimental philosophy*, as it began to be called about four-hundred years ago, is the understanding that all volumetric systems in the universe, containing matter, can be expanded by *heat addition*, which cause volume expansion, then *heat subtraction*, which causes volume contraction, and the difference of this heat arithmetic, is what is defined as the 'equivalence value of all uncompensated transformations', in Rudolf Clausius (1865) explained things. One has but either to accept this new theory, which we have greatly over-simplified, or to overthrow it. As this new view of things, has been accepted and applied universally, up to the present day, human societies included, we will endeavor to present this new view, applicably, along the way, discarding any hazardous subject matter we might, per force, be required to discard, unlearn, or usurp, which are too many to list at this point.

2. Gods | Neter, Theta Θ, and the Alphabet

> "If **ignorance** of nature gave birth to gods, **knowledge** of nature is made for their destruction."
> — Baron d'Holbach (1770), *The System of Nature*; paraphrased or restated by Percy Shelley (1811) in *The Necessity of Atheism*

Chapter point: to introduce the original model of 'gods' as power, give the etymologies of chemistry and thermodynamics, and give overview of the roots of the Egyptian-based English alphabet [length: 10-pgs].

The name 'god' etymologically derives, in the predominate *active* world religions sense of the matter, from the Egyptian term neter Ntr (Netjer, Netcher), represented by the '𓊹' hieroglyph, the symbol of a 'hatchet' (Birch, 1848), 'weapon' (Brugsch, 1862), or 'axe' (Budge, 1904), which in plural form, 'neteru', is represented by the combined hieroglyph set of symbols '𓊹𓊹𓊹', meaning 'gods'. When the neter symbol is shown groups of eight (8) axes: as '𓊹𓊹𓊹𓊹𓊹𓊹𓊹𓊹', or **Ogdoad**, in Greek, e.g. Hermopolis Ogdoad, or nine (9) axes as: '𓊹𓊹𓊹𓊹𓊹𓊹𓊹𓊹𓊹', or **Ennead**, in Greek, e.g. Heliopolis ennead, it refers to a 'paut' or group of gods, generally symbolic of the strength of the 'military power' of the given city.[1]

In a modern sense, to say, in ancient Egyptian speak, that a nine-axe city has more god-based military power than a three-axe city, is equivalent to saying that a 200+ nuclear warhead country, e.g. US, Russia, China, has more 'military power' than a 100+ nuclear warhead country, e.g. India, Pakistan, North Korea. The term 'god', accordingly, in its original definition sense, was a synonym for '**power**', be it military power or social power.

The term 'power', in modern terms, is now defined, via the science of thermodynamics, in a quantifiable manner, as *work per unit time* (Watt, 1783). The term 'work', likewise, is defined, no longer by the phrase 'god works in mysterious ways', but as being mechanically *equivalent* to heat (Joule, 1843), specifically a unit of work W divided by a unit of heat Q, which has unit of joules.

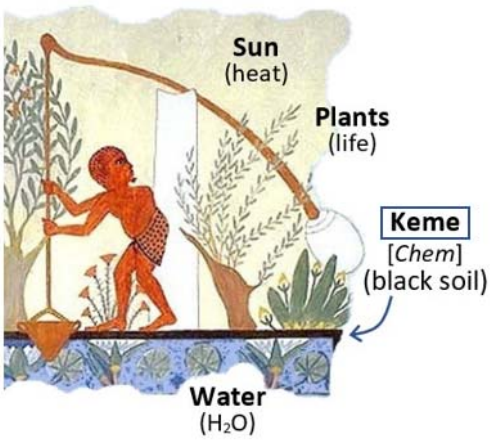
The term 'heat', similarly, is now understood, in conceptual terms, as a quiddity of motion of matter (Bacon, 1620); quantified, as we will explain in later chapters, in terms of what are called an *exact* different units of entropy dS, defined as the product of the absolute temperature T of a body and the *inexact* differential δQ of heat, or TδQ, defined at the point where the unit if heat 'δQ' enters or leaves the body (Clausius, 1865); which is mechanistically understood, in particle physics terms, as a quantum electrodynamic 'exchange force' interaction of photons and electrons (Feynman, 1985), which moves attached nuclei.

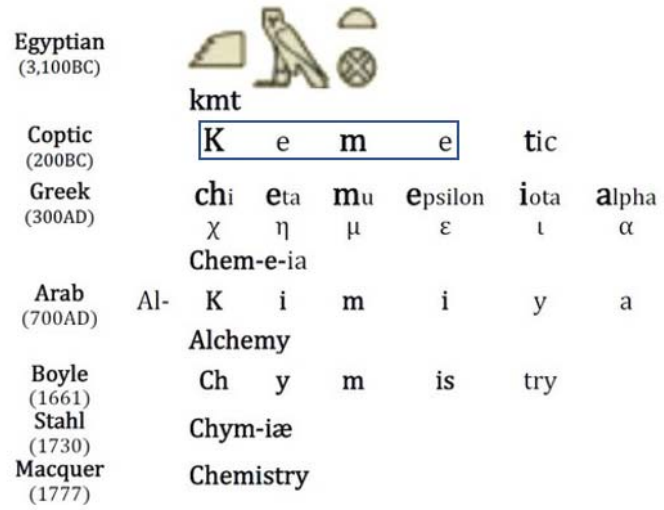
The ancient astro-theology based mythical concept of god, accordingly, has been 'reduced' to thermodynamics, and hence becomes superfluous. A short *history of god*, in order to necessitate this god reduction, will be touched upon in this chapter.

2.1 | CHEM-istry etymology | Keme

The term 'chemistry', or *chem*-istry, derives from the Egypt hieroglyph **kmt** meaning 'black' as follows: The prefix *chem*-, in more detail, is from the Egyptian '**keme**', meaning 'fertile black soil, from the Egyptian hieroglyph 'km.t', meaning 'black', a reference to the alluvial, overly-fertilized, black soil, rich in minerals and nutrients, and a good crop soil, deposited annually on the banks of the Nile River, following

the yearly Jun to Dec 150-day flood, the ‘black’ part of the soil, being carried down from Ethiopian mountains, with the flowing waters of the melting snow.[2]





Hence, Egypt was called the country of the ‘black land’, as contrasted with the country of the ‘red land’, the surrounding desert. The early forms of chemistry practiced in Egypt was thus called the kemetic art, aka the ‘black art’, as early versions of *alchemy* were named, before becoming the science of chemistry in the 17th century.

In the first millennium BC, the Greeks, from Lycurgus (850BC) to Manetho (275BC), all travelled to Egypt to study in their great colleges, after which they began to call the so-called **‘kemetic art’**, or ‘black art’, as it later came to be called, related to recipes for working with metals, dying cloth, and for preparing false silver, false, and false gems. This is evidenced by two Egyptian chemistry papyri (c.300AD), found in a tomb in Thebes, namely the Leyden Papyrus X and the Stockholm Papyrus, by the Greek name χημεια or ‘Chemeia’, such as found in the works of Zosimos of Panopolis (300AD). This became *alchemy* in Arabic and eventually *chemistry* in 17th and 18th centuries. The following is a basic overview, to this effect:

> “Chemistry implies that the amalgamation of metals was its first occupation, and many see in that form of the word a reference to *Chemia*, which is, according to Plutarch, an old name of Egypt, in which this amalgamation was first practiced with success. The word druggist came from the drugs he sells.”
>
> — James Mitchel (1908), *Significant Etymology: Roots, Stems, and Branches of the English Language* (pg. 142)

In modern times, the details of processes such as plant growth, in respect to this ‘keme’, as shown by the Egyptian planting crops above, are well known, as explained by the actions of light, energy, heat on 92 elements, as covered in basic treatises on plant physiology.

Five-thousand years ago, however, there were only four elements: earth, air, water, and fire, not 92, and in relation to plant growth, this was not understood not in terms of ‘synthesis’, but in a cosmo-theological sense, wherein each element was considered a different god: water (Nun), sun (Ra), earth (Atum), and air (Shu). Hence, the Egyptians, instead of thinking of heat, as we do now by the symbol δQ, an inexact partial differential, as we now defined things, thought of heat, or the radiance of the sun, as being the power of the sun god Ra, or an equivalent sun god alternative, e.g. light rays thought of as the long outstretched ‘fingers’ of the sun god Aten. This latter description, of note, is from where, in the Old Testament, the story of god writing the ten commandments, on a stone tablets, with his ‘finger’ derives.

These ancient sun beliefs, without going into detail at this point, are rooted, in various unseen ways, in the modern cultural language and heritage of all our minds. To exemplify, we will simply point out the fact that, in the English-speaking world, the name ‘Father Ra of Egypt’, is known by the name Abraham or Ab-Ra-*ham*, the suffix -*ham* pronounced ‘**chem**’ in Hebrew, which is the same root as found in the name **chem**-istry. In the Hindu world, similarly, the sun god Ra is known as Brahma or B-Ra-*hma*. In the modern scientific world, the -*ham* or -*hma*, resounds as the root of ‘chem’ in the name *chem*-istry.

Chemistry, Abraham, and Brahma, accordingly, all have the same root ‘keme’ or kmt, and hence are rooted, etymologically, in ancient beliefs about sun gods born out of the land of the keme or black fertile soil.

2.2 | THERMO-dynamics etymology | Θ + Δ

The etymological development of 'thermodynamics', accrued as follows:[3]

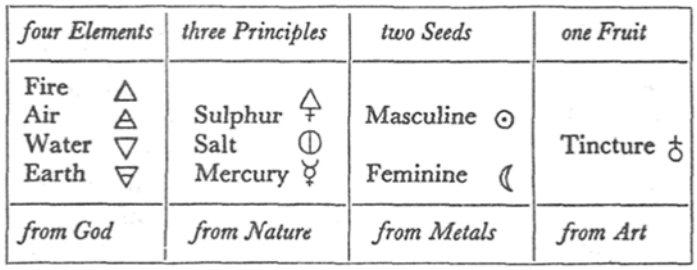
	Person	Date	Term
1.	Heraclitus	570BC	Energon (en-ergon)
2.	Aristotle	350BC	Dynamis + Energia
3.	Galileo	1602	Study of effect of gravity on falling bodies
4.	Newton	1686	Mathematical principles of natural philosophy
5.	Gottfried Leibnitz	1689	Dynamics
6.	**Sadi Carnot**	**1824**	**Mechanical theory of generalized heat engines**
7.	Gustave Coriolis	1829	Dynamode = 1000kg lifted one meter
8.	William Thomson	1848	Carnot's theory of the motive power of heat
9.	William Thomson	1849	Thermo-dynamic = perfect engine of Carnot's theory
10.	William Thomson	1851	Dynamical theory of heat
11.	**William Thomson**	**1854**	**Thermo-dynamics**
12.	William Rankine	1855	Energetics
13.	**Rudolf Clausius**	**1865**	**Mechanical theory of heat**
14.	**James Maxwell**	**1867**	**Θcs**
15.	Gustave Hirn	1868	Thermodynamics
16.	**James Maxwell**	**1876**	**ΘΔcs**

The core coining, of the science of thermodynamics, was done by William Thomson in 1854, as we will discuss. Thomson was followed by Rudolf Clausius, who, in 1865, building on his work, founded the science of thermodynamics, albeit under the name 'mechanical theory of heat'. The finalized, globally accepted, unhyphenated, term 'thermodynamics', was employed, in French, by Gustave Hirn, in 1868, wherein, this new science, namely of the study of the operations of heat, work, and energy, on bodies or systems of bodies, became a new accepted branch of science, and no longer just a 'theory' as Clausius had described his program of study.

Now, in respect to the 'symbols' used in thermodynamics, in the last of these name usages, namely row fifteen, we see James Maxwell, in 1876, referring to the new science of thermodynamics, in his communications to Peter Tait and William Thomson, as '**ΘΔ**' or Theta-Delta-ics. As to where Maxwell conceived or learned this peculiar Greek notation shorthand for thermodynamics, we can only conjecture?

We do know, however, that in 1825, James Forbes, aged 16, at the University of Edinburgh, was contributing articles to the *Edinburgh Philosophical Journal* under the anonymous name symbol of 'Δ' and that from 1836 to 1844, in the *Transactions of the Royal Society*, he published four articles on 'researches on heat', themed on his undulatory theory of heat. Secondly, we know that Forbes mentored William Rankine, at the Edinburgh University, and that Rankine gave Forbes two copies of this 'molecular vortices' hypothesis of atomic structure and his 'vortex heat generation' theory. Rankine, in turn, not only went on to become one of the core handful of thermodynamics founders, albeit a second ranked one, but he was one of the core links in the Thomson, Tait, Maxwell letter communication network.

The use of the Delta 'Δ', historically, a symbol classically employed, represents either fire, change, or heat, as an assignment that goes back to at least Pythagoras (who also studied in Egypt); the adjacent diagram being one example of a Pythagorean-schemed alchemical symbols table published in Nuremberg, Germany, in 1766.[4]



Likewise, we see upside down triangle symbol '∇' for water. These two symbols, fire Δ and water ∇, haven been built into chemistry and alchemy for many centuries, going back millennia, to the Egyptians, as we will explain. Here, on an aside, we note that the 10 alchemical things in this Nuremberg alchemical

symbols table, namely: fire, air, water, earth, i.e. the ‘four elements’, sulphur, salt, mercury, the ‘three principles’, male and female, the ‘two seeds’, and the tincture, the ‘fruit’, at this period in time, were conceived as being the tetractinal summation of Pythagoras (1 + 2 + 3 + 4 = 10), and thought to be allocated or associated with to the ‘philosopher’s stone’, a legendary alchemical substance thought to be capable of turning base metals such as mercury into gold. This is an example of what is called the ‘Pythagorean delusion’, namely getting one’ mind swept up in number patterns, thinking, therein, that the is greater meaning in the number pattern, that as compared with what actually matches up with reality. Many mathematicians fall prey to this focus on number patterns.

Now, to get to the point of things, the employment of Theta ‘Θ’, by Maxwell, in referring to Thermo-Dynamics, in shorthand, as ‘ΘΔ’, leads us into refreshingly, semi-uncharted territory, etymologically speaking. In short, to awaken the mind of the reader, we will but simply point out that the Greek Theta ‘Θ’ is the root letter of the following six key, seemingly unrelated, yet historically-dominating terms, divide into mythical and scientific categories, respectively:

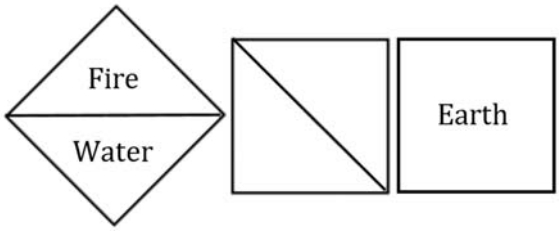
	English	Greek	
1.	**Th**eos	Θεός	Mythical
2.	**Th**eology	Θεολογία	
3.	**Th**eogonia	Θεογονία	
4.	**Th**ermal	Θερμικός	Scientific
5.	**T**emperature	Θερμοκρασία	
6.	**Th**ermo-Dynam-ics	Θερμοδυναμική	
	ΘΔ-ics	Maxwell (1876)	

The Greek letter Theta ‘Θ’, in short, as is historically agreed upon, as we will explain, via cited historical consensus, is the symbol of the *sun* or one of the Egyptian *sun gods* in its various incarnate forms or cultural rescripts.

The Greek letter Delta ‘Δ’, while not so historically certain, in regards to etymological accuracy, is generally acknowledged, according to what is called ‘accepted history’, which is code for culturally accepted history, to be a reference the *triangle* shape of the ‘Nile delta’, the watery fertile upside down triangle-shaped green crop-growing region, of the Nile River, as this area of land was called or named by the Greeks, amid their Egyptian to Greek translation of things.

Now, while the Greeks may have named the green fertile region as the Delta, symbol ‘Δ’ aside, it seem more logical that the Δ-shaped fire or sun god birthing pyramids of Giza, shown above left, build near Memphis and Heliopolis, in 2500BC, are truer etymological basis of the Greek Delta symbol; whereas, in ancient Egyptian Greek alchemy, the upside down triangle ‘∇’ became the symbol for water, possibly in reference to annual flooded upside down triangle-shaped region of the crop-growing region called ‘Delta’ by the Greeks.

While we can only speculate, as to these ‘Δ’ (fire) and ‘∇’ (water), which have been handed down to us, we will note that the fire symbol on top of the water symbol becomes a square:



which forms a square '□', which via Egyptian-learned Pythagorean tautology, in the mind of Plato, became the cube, as the symbol of the earth, the origin of the phrase 'four corners of the earth'.

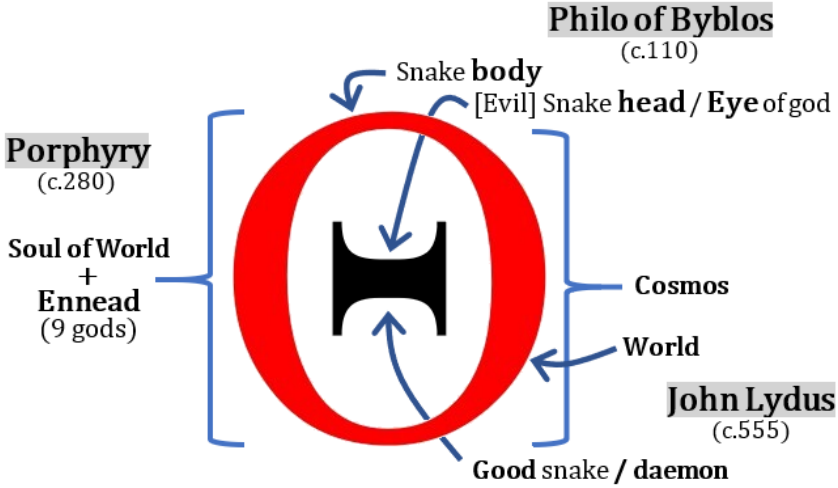
The Theta symbol 'Θ', as now employed, as a circle with some kind of accentuated line inside of it, according to historical consensus, derived from an aggregation or synthesis of the myths and astro-theology behind the sun with an 'x' symbol, '⊗', which is part of the hieroglyph for the city of Heliopolis, below left, and the symbol of the sun or sun god, Ra or Atum-Ra, or possibly another sun god variant, depending on period, of a circle with a dot inside 'ʘ', such as shown below center, and or the ancient symbol of the sun with a snake around it or inside of it, below right, either with or without the eye of the sun god inside:

Hieroglyph of Heliopolis (2800BC) — **Give life, Ra-like forever** (di-ankh, Rā-ma, djet)

In c.110, Philo of Byblos, a Roman antiquarian writer of grammatical, lexical and historical works in Greek, reported that the Greek Theta owed its form to the Egyptian habit of designating the deity by a ringed serpent, with its head turned inward, the dot representing the eye of god in the world.[5] The snake doing nightly battle with the sun god, either Ra or Horus, corresponds to what we now call the Ouroboros. The eye of the sun corresponds to what we call the eye of Ra or eye of Horus, depending.

In c.280, Porphyry, a Roman philosopher, and student of Plotinus, stated that the Greek theta corresponds firstly to the 'soul' of the world, which correlates to the 'world soul', retrospectively, and also, more importantly, that the significance of number 'nine' (9), which he says was numerically representative of the famous nine sun god family known as the 'Ennead', by the Greeks, as explained in the Heliopolis creation myth, which is the basic theory behind the constructions of the pyramids.[5]

In c.555, John Lydus, a Roman antiquarian scholar, stated that the Egyptians used a symbol in the form of a Theta for the 'cosmos', with an airy fiery circle representing the world, and a snake, spanning the middle, representing the *agathos daimon* or 'good spirit'; which again seems to correspond to what we now call the 'ouroboros'.[5]



The adjacent diagram summarizes of these three views of Philo, Porphyry, and Lydus, in regards to what the Theta symbol represents. These conjectures, however, to note, are attempted at some 900 to 1400 years *after* the Theta symbol became part of the newly formed Greek alphabet.

We will also point out that, presently, no satisfactory explanation of the reason behind the 'x' symbol of the sun '⊗' found in hieroglyph for the city of Heliopolis, which, per above opinion, is behind the middle bracket in the present form of Theta? Classically, hieroglyphic scholars have simply labeled it as the generic symbol for 'city'. Others will say that it was simply copied from the Phoenicians 'Tet' symbol '⊗'? The Phoenicians, however, as has been

pointed out by Charles Bunsen (1848), copied or derived all their gods from the Egyptians. In this sense, have conjectured that the 'x' symbol has something to do with the sun being re-born, on Dec 15, in the constellation of the 'Southern Cross', or Crus Australis, such as popularized by Peter Joseph, in his 2006 *Zeitgeist* video, via citation to Dorothy Murdock, Gerald Massey, among others. Massey (1883), e.g. points out that the southern passage of the telescopic tubes of the great pyramid points directly to the star Centauri, which rises over the Southern Cross.[7] Others have conjectured that the cross in the sun symbol has something to do with the four cardinal points. We will leave this an open question.

The earliest extant reference to use of 'Theta', in Greece, in a published work, pottery usages aside, which tended to employ the dot in circle symbol, in a dominate term sense, occurred when Hesiod penned his *Theogony*, or book on the generation of gods, which is primarily a god reduction rescript of the Egyptian pantheon.[6]

The ancient symbology of the evil snake doing battle, nightly, with the 'good' sun, however, is a core religio-mythology, that goes back at least 2,200-year *before* the Theta symbol was introduced, and the myth evolved or went through at least five rescripts. The following two quote, by Wallis Budge, gives a cogent summary of the four main rescripts of the Theta symbol, or god-snake motif, over the last 5,000-years:

> "The mythological and religious texts of all periods contain many allusions to the fight which Set waged against Horus, and more than one version of the narrative is known. In the **first and simplest form** the story merely records the natural opposition of day to night, or night to day, and the two combatant gods were Heru-ur, or Horus the Elder, and Set. In its **second form** the two combatant gods are Ra and Set, and the chief object of the latter is to prevent Ra from appearing in the East daily. The form which Set assumed on these occasions was that of a monster serpent, and he took with him as helpers a large number of small serpents and noxious creatures of various kinds. The name of the serpent was **Apep** [ ] or Aaapef [ ], which is preserved in Coptic under the form [ ], but he was also called Rerek [ ], and since he was identified with a long series of serpent monsters he had as many names as Ra. In the **third form** of the story the combatant gods are Osiris and Set, and we have already seen how Set slew his brother and persecuted his widow and child, and how he escaped punishment because Osiris had, at the time of his death, none to avenge his cause. In the **fourth form** of the story the combatant gods are Horus, the son of Osiris and Isis, and Set, and the avowed intention of Horus is to slay him that slew his father Osiris."
>
> — Wallis Budge (1904), *The Gods of Egypt, Volume Two* (pg. 254)

Likewise, the following quote, by Gerald Massey, summarizes the so-called **fifth form** or fifth incarnation or rescript of the ancient tale or myth of good vs evil:

> "The Hebrew Satan was the Egyptian **Set**, who became the evil one of the later theologies as an anthropomorphic rendering of **Apep** the 'serpent of evil'. Sut was one of the seven sons of the old 'first mother', the goddess of the Great Bear in the astronomical mythology [astro-theology]. He was not one of 'the sons of god', as there was no god extant when he was born. Sut was brought forth twin with Horus, and first born as the adversary of his brother Osiris. In a truer version of the mythos the conflict was in phenomena that were physical, not moral."
>
> — Gerald Massey (1907), *Ancient Egypt: the Light of the Modern World, Volume Two* (pg. 493)

Having now rendered the basic outline of the Theta symbol to the sun connection, the following alphabet evolution table, shows how these sun symbols, were carried over, from Egyptian hieroglyphs, to the Phoenician alphabet, to Greek alphabet letters:

	Egyptian hieroglyphs [2500BC] (many symbols)		Semetic-Sinaitic [1500BC]	Phoenician [1050BC] (22 letters)	#	Greek alphabet [800BC] (24 letters)		Etruscan [300BC]	Roman [800AD] (26 letters)	Derived Terms
1.	Phoenix (bennu)				aleph	1	A Alpha	α alpha		A	Atum, Adam
2.					beth	2	B Beta	β beta		B	Ab; Ab-raham; B-rahma

3.							X Chi	χ chi		C	
					Y way	3	F Diagamma	F diagamma			
4.	Pyramid (Atum)				◁ daleth	4	Δ Delta	δ delta		D	Δ, ΘΔ-ics, derivative, derivation
5.					∃ he	5	E Epsilon	ε epsilon		E	En-ergon (energon), energeia, engines, experiments, equations, energy.
						6	F Diagamma	F, ς diagamma			
6.							Φ Phi	φ phi		F	Frieie energie (see: free energy)
7.					⅂ gimel	3	Γ Gamma	γ gamma		G	Gibbs
8.					⊟ heth	8	H Eta	η eta		H	Helios, heat; heat content; enthalpy
9.					⅁ yodh		I Iota	ι iota		I	
10.										J	Joule
11.					⊁ kaph		K Kappa	κ kappa		K	Kelvin
12.					∠ lamedh		Λ Lambda	λ lambda		L	Love
13.					ᴟ mem		M Mu	μ mu		M	Mass, Matter
14.	Water (Nun)				ϟ nun		N Nu	ν nu		N	Noah, Nuh, number, new, neo, nil, negative, noosphere
15.					○ ayin		O Omicron	o omicron		O	
16.					⅂ pe		Π Pi	π pi		P	Pressure
					⅄ sade		M san				
17.					φ qoph		Ϙ qoppa		⚲	Q	Quantity
	Sun (Ra)	, Θ	Ouroboros		⊗, ⊗ teth / tet	9	Θ Theta	θ theta	⊕, ⊙	Th	Theos, theology, Theodorus, Theophrastus, Thanatos (see Mor). therm, thermal, temperature, thermo-, ΘΔ, think, thought
18.					◁ res		P Rho	ρ rho		R	Gas constant
19.					W sin		Σ Sigma	σ, ς sigma		S	Entropy
20.					X taw		T Tau	τ tau		T	Temperature
21.							Y Upsilon	υ upsilon		U	Internal energy
22.										V	
23.							Ω Omega	ω omega		W	Wahrscheinlichkeit (see: Multiplicity)
24.					⋕ samekh		Ξ Xi	ξ xi		X	
25.							Ψ Psi	ψ psi		Y	
26					I zayin	7	Z Zeta	ζ zeta		Z	Proton number (see: periodic table).

Numerically, in respect to the Greek numbers 1 to 9, as listed in the alphabet table, Ra, the main sun god of Egypt, or in his syncretistic form of Ra-Atum, a c.2500 joining of the gods Ra + Atum, together with his or

their eight sibling gods, namely: Shu, Tefnut, Geb, Nut, Osiris, Isis, Set, and Nephthys, as we will discuss further in the 'Sun gods' and 'Ancient Egypt' sections, formed a group of gods called by the Greeks the '**Ennead**' or Heliopolis Ennead, meaning group (or *paut*) of nine (9) gods. This Ennead (Ra + eight children sun gods), was symbolized, in hieroglyphs, by the Egyptians, as nine axes, each axe, representative of the 'power' of a given god:

Ennead =

power here being thought of in the sense of war power. In the mind of a typical ancient Egyptian, however, the axes would be ordered, one axe for each god, as follows:

Ennead = (**Ra**) + (Shu & Tefnut) + (Geb & Nut) + (**Osiris**, Isis, Set, Nephthys)

The origin and generation, of this group of original creation myth nine gods, is explained by the famous Heliopolis creation myth, covered shortly. The numerical value of Theta equaling nine, therefore, is code for the Theta Θ being symbolic of BOTH the supreme sun god, e.g. Ra or Atum-Ra, plus the Ennead, or nine-god family derived from this sun god.

With these details in place, we next point out the peculiar fact that the 'numerical sum', per the Greek numerical system, of the letters in the word Theta (Θῆτα), according to 'isopsephy', a learning technique, or cypher technic, employed by early Greeks, who used pebbles arranged in patters to learn arithmetic and geometry, has the same *numerical value* (318) as the term Helios (Ηλιος), as follows:

Θῆτα (**Theta**) = **9** + 8 + 300 + 1 = **318**
Ηλιος (**Helios**) = 8 + 30 + 10 + 70 + 200 = **318**

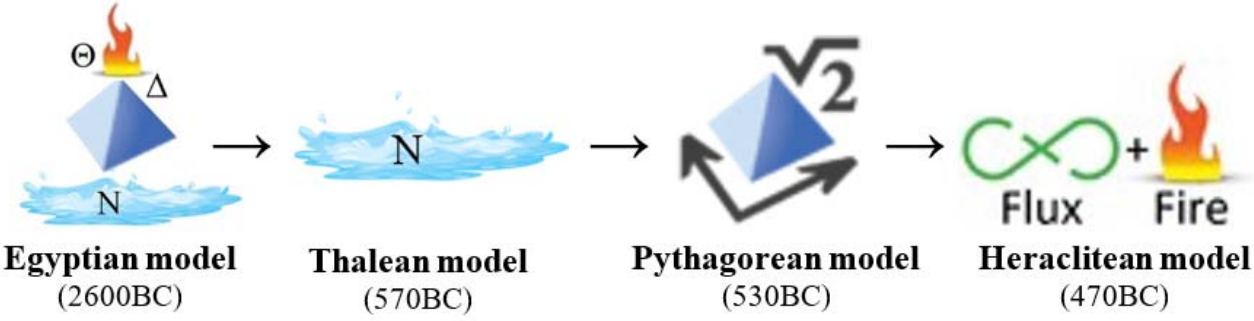
The number 318 is the number of the diameter of the perfect so-called 'solar circle', having a circumference of1,000 units, namely the 'monad' in Greco-Hebrew arithmetic.[8]

Moving forward, we acknowledge that the 'triangle', throughout human history, at least as far as extant alchemical texts illustrate, has been the symbol of 'heat' or 'fire', which in the post thermodynamics era, became the symbol for change, e.g. the change in the internal energy, symbol U, of a system, defined as follows:

$$\Delta U = U_{final} - U_{inital}$$

where U_{final} (or U_F) is the internal energy at the *final* state, of existence, of the system, and $U_{initial}$ (or U_I) is the measure of the internal energy at the initial state, of existence, of the system, and where Δ signifies the change or final minus the initial values for each measure.

In c.570BC, Heraclitus, presumably after studying in the colleges of Egypt, as most Greeks did during these centuries, developed his '*en*-ergon' model, *-ergon* meaning 'work', and en- meaning 'in', 'to go into', or 'cause to be', of things, wherein flux or change Δ and fire Θ was the basis of all things. The Heraclitus model is shown below, in the context of the other models of this period:



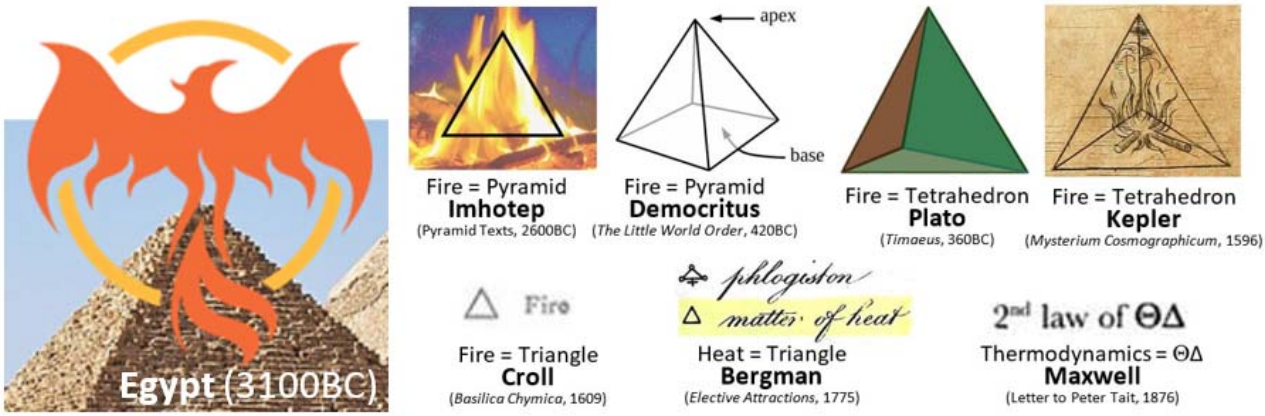
In 350BC, Aristotle, in his *Physics*, building on the early en-ergon ideas of Heraclitus, along with the four element and two force model Empedocles, and atoms and void model of Democritus, introduced the term *dynamis*, meaning 'potentiality', along with a second term *energeia*, meaning 'being at work', or something to this effect. These meanings are, to note, different from the modern day meanings, but his terminology stuck.

In 1602, Galileo, after doing experiments with falling bodies and gravity, broke with the older models of Aristotle, and went on, over the next thirty years, to found the outline or basis of what we now consider to

be modern ‘dynamics’. This Galilean version of dynamics was refined by Newton, Leibnitz, Lagrange, and Hamilton.

In 1875, Clausius had subsumed the Hamilton version of dynamics, which was used to formulate the internal energy, symbol U, of a system, after which time *dynamics*-models + heat-models became the science of thermo-*dynamics*, as a new standalone universal science.

In sum, the basic model of how Pythagoras, and following him Democritus (c.420BC), Plato (360BC), Kepler (1596, Croll (1909, Bergman (1775), and Maxwell (1876), were taught that fire relates to a Delta symbol ‘Δ’ is outlined below:



The standard model, in the days of the pyramids, in Egypt, was a creation myth which said that first the world existed as some type of primordial watery abyss or flood, water being hieroglyphically symbolized by water waves 〰 , or the water god Nu, or the symbol N, as in Noah, in English alphabet notation, out of which land, in the form of a pyramid, symbolized by Delta symbol ‘Δ’, arose, out of the tip of which the sun burst forth, carried by a benu bird or ‘phoenix’, as Herodotus (450BC) named it.

The following, to put things into perspective, are views representative of the Egyptian to Greek cultural transmission of this sun born out of a pyramid, or capital Delta Δ shape, etymology:

> “Though it was primarily with reference to the properties and powers and motions of bodies that they assigned them their shapes, the latter are inappropriate. For instance, since **fire** is mobile, and since it heats and burns some made it a sphere, **others a pyramid**. They are the most mobile since they are in contact with the fewest things and have the smallest base, the most productive of heat and burning because the one, the sphere, is an angle all over, while the other, the pyramid, has the sharpest angles, and heat and burning are produced by the angles, so they say. Next, if what is burned is set on fire, and **fire is a sphere or a pyramid**, what is burned has to become spheres or pyramids.”
>
> — Aristotle (c.350BC), *De Caelo* (306a26-307b5)

> “There is also the problem of **why a flame is shaped like a pyramid**. Democritus says that as its extremities cool down it contracts into a small shape and eventually tapers to a point.”
>
> — Theophrastus (c.320BC), *On Fire* (52)

As heat, historically, as we see, has been associated with the pyramid or delta symbol, so to did the Delta symbol Δ became the symbol of heat, change, or transformation in the science of thermodynamics.

> “Thermodynamics is the kingdom of the delta.”
>
> — Clifford Truesdell (1980), *The Tragicomical History of Thermodynamics: 1822-1854* (pg. 3)

In respect to the thermodynamically important symbol ‘S’, which derives from the Greek Sigma ‘Σ’, the latter of which being employed by Leonhard Euler in 1755 as the mathematical *summation* symbol ‘ ∑ ’, while we cannot digress on this fully until we get to the Clausius chapter, we will point out that the symbol S, in the sense of summation, was employed by Rudolf Clausius in 1865 for the term ‘entropy’, conceptualized by him as the ‘sum’ of the all of the ‘transformation equivalents’ going into and out of any system in the universe, in one ‘Carnot cycle’. We will learn these important terms as we progress. The important point to see here, is that entropy is NOT a measure of disorder, it is a measure of an exact differential transformation equivalent.

Suffice it to say, accordingly, prior to our soon to come engagement in *chemical thermodynamics*, aka the 'Kemetic art of ΘΔcs', as Maxwell might vicariously say, it behooves one to learn a bit of the ancient Greco-Egyptian theories of heat and chemistry, so as to situate things in historical context, not only in respect to the heat symbol, but also to the main sun gods or 'heat gods' as they came to be conceptualized, per reason that belief in them, in modern day cultural times, is still prevalent, albeit sublimated, in forms such as the prophet Abraham or the god Brahma.

In sum, in this chapter, our point here was not to suggest that Thomson, Clausius, and Maxwell had Egyptian mythology, religion, or secret coded symbolism in mind when they coined what we now refer to as thermodynamics, but rather to point out that our language as a culture, scientifically and religiously, is deeply imbedded with heat-based language, much of which being held strongly by some of our most cherished beliefs about being, becoming, and existence. We have to get all of our cards out on the table, before we can correctly play the game, in short.

Synopsis: (add)

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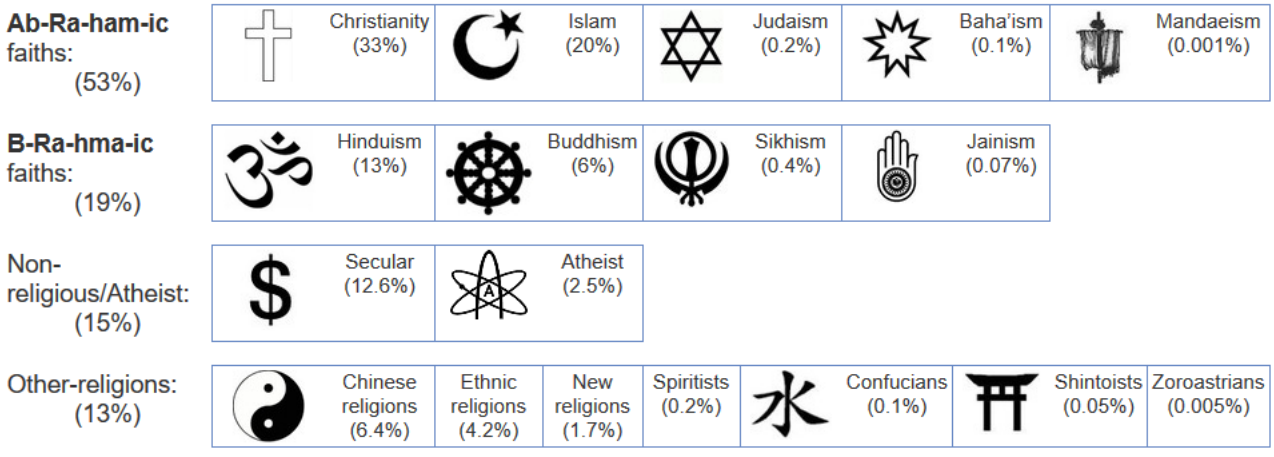
7. Massey, Gerald. (1883). *The Natural Genesis: Second Part of a Book of the Beginnings, Containing an Attempt to Recover and Reconstitute the Lost Origins of the Myths and Mysteries, Types and Symbols, Religion and Language, with Egypt for the Mouthpiece and Africa as the Birthplace, Volume Two* (pg. 337). Williams and Norgate.
8. https://hmolpedia.com/page/318
9.

3. Gods | Ra and Heliopolis

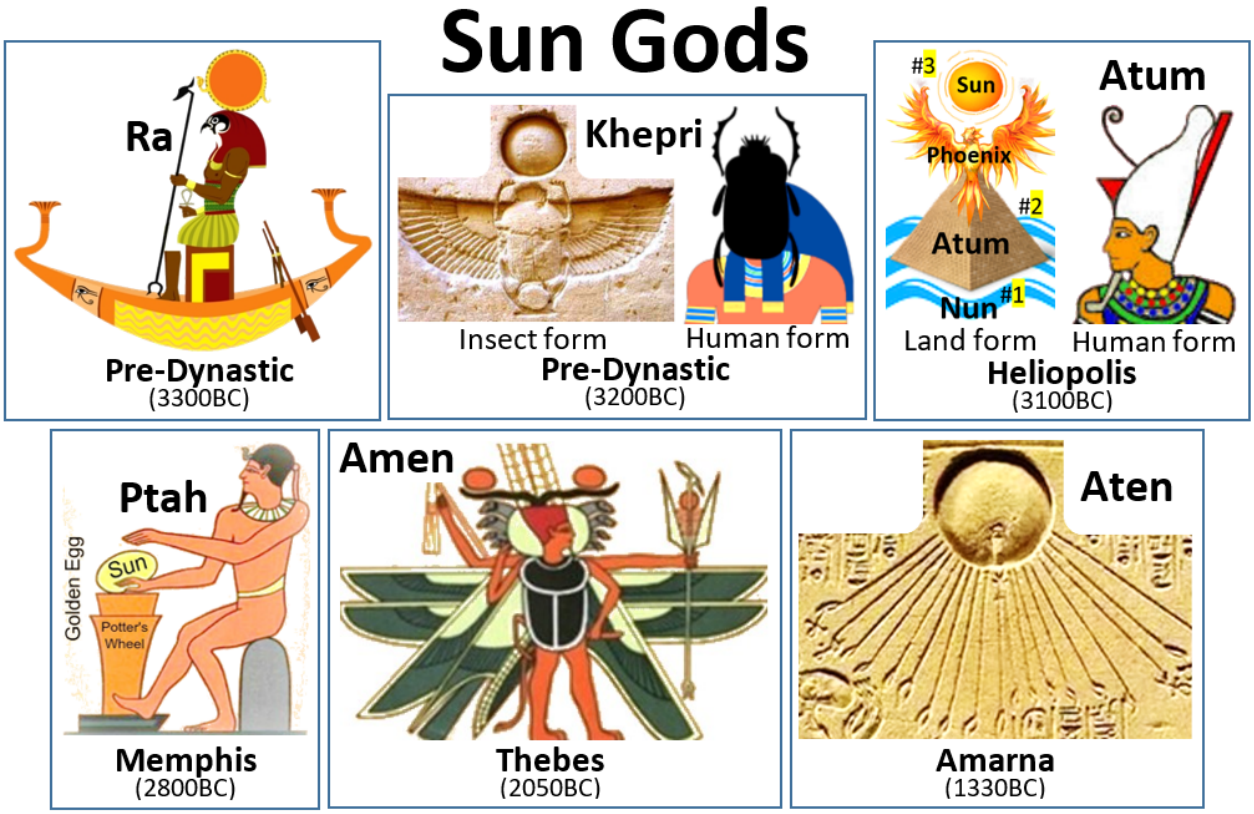
> "This name Abram or Abraham at once suggests the mythological nature of the history. It is one of the innumerable instances in which, in the ancient world, the sun, or a priest of the sun, was claimed to be the patriarch or first ruler or lawgiver of many nations. In Egypt *'Ra'* was the Sun, and Osiris an incarnation of the sun, was the first ruler there. Brahma was the first lawgiver of the Hindus, and there is little doubt that 'Brahman', as stated by Thompson, in his notes to the Bhagavad-Gita, was originally a name for the sun. **This word 'Ra', meaning 'bright', is contained not only in the Egyptian mythological names connected with the sun**, but a long list might be given, in which it appears in the names of all the sun heroes of all the Indo-Aryan languages, just as the cognate word 'El', 'bright', appears, in the same way, in the names of the Semitic sun heroes."
>
> — Thomas Scott (1876), *The Serpent in Mythology* (pgs. 8-9)

Chapter point: Introduce Egyptian sun god based religio-mythology, and to give the outline of its modern form, in terms of what are called rescripts, in the Abrahamic and Brahmic faiths [length: 11-pgs]

The following shows the distributions the world's religious beliefs, which are divided according to the sub-branches of either the Abrahamic (53% world belief) or Brahmaic (19% world beliefs), both originally being 'Father Ra of Egypt born out of the Nun or Keme' belief systems, prior to their cultural rescripts, which shows that, in large, Ra-based belief systems currently dominate the mindsets of 72% of the modern world, otherwise known in ancient days as Anunian theology or Ra theology (aka Egyptian mythology):



Historically, Ra, the sun god, took on many incarnate forms. The following shows the five main *sun gods*, aka 'heat gods', of Ancient Egypt, are shown below, upon which all ancient models of human origination, existence, and becoming are based, baring digression on Yellow River based belief systems, which accounts for a marginal section of the current world population:



Firstly, above left, is **Ra**, a falcon-headed god, on whose head rests the sun disc, surrounded by a snake, who rides a solar barque though the sky carrying the sun and or turns into a bird and flies the sun through the sky on its head; secondly **Khepri**, a scarab beetle who either flies the sun through the sky each day and or rolls the sun through the sky only to bury it each night; three **Atum**, a god who either takes the form of the first land mound that arises from the primordial watery abyss, out of which the sun bursts forth in the form of the phoenix; forth **Ptah** who makes a golden egg out of which the sun is born; fifth **Amen**, who is said to be a morph or reincarnated form of the previously named gods; and sixth **Aten**, who was considered a heat disc, surrounded by a snake, whose sun rays were the long out-stretched arms of god. The semi-scientific poetic descriptions of this last god, Aten, according to some, e.g. Karl Luckert (*Egyptian Light and the Hebrew Fire*, 1991), boarder remotely on naturalistic scientific atheism.

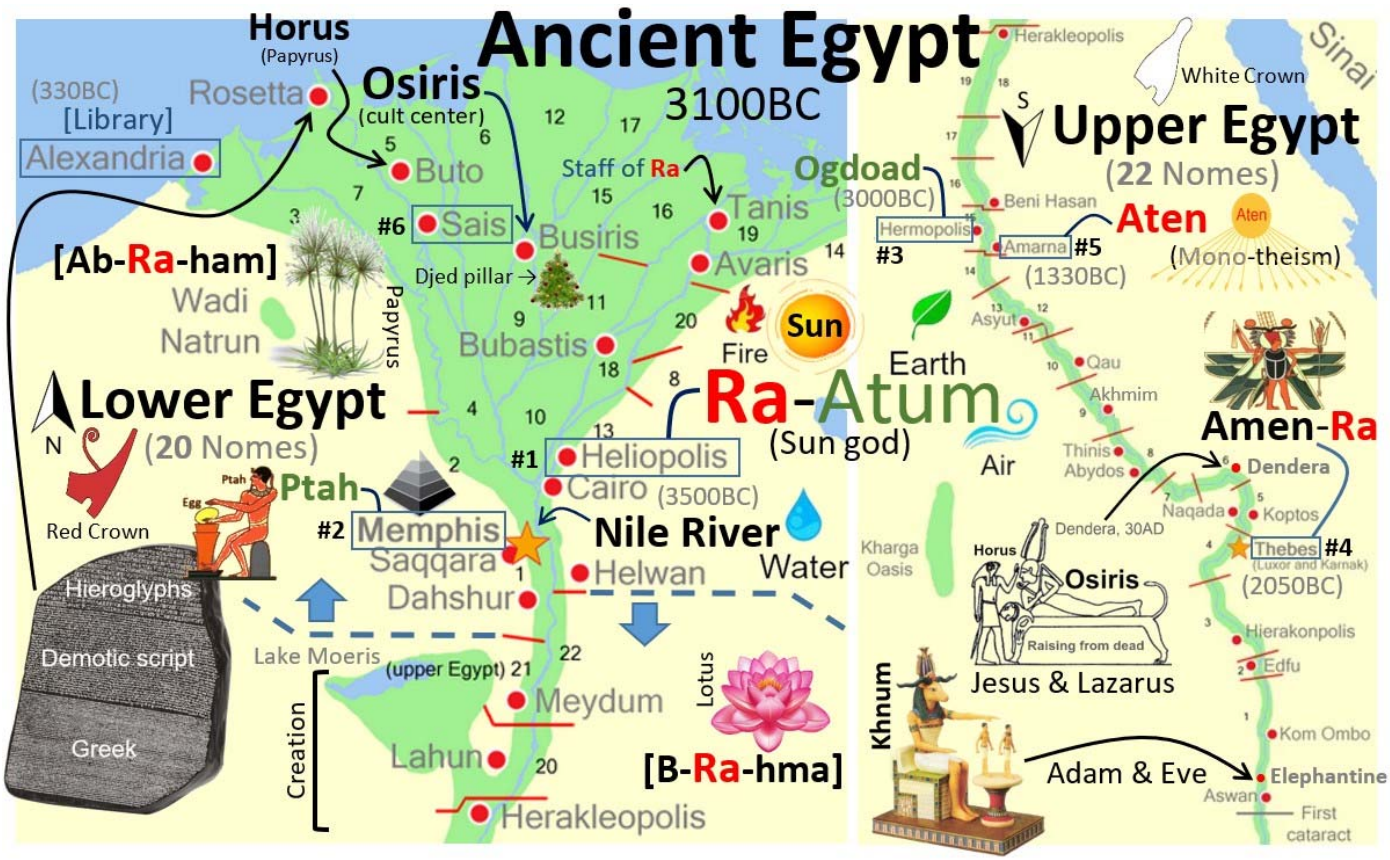
To the shock of many if not most of the aspects of all of these six main sun god models have been transmitted forward, in disguised form, into the majority of the world's modern religions, and hence into the taught childhood cultural knowledge; e.g. most do not know that the long outstretched 'finger of god' that penned the Ten Commandments, onto two stone tablets, are rescripts of the sun ray arms and fingers of Aten.[1] Many, to note, do not take well to this unprogrammed view of things:

> "The number of people on the **borderline of insanity** in a big country is simply appalling, and these seem especially addicted to believing themselves, saviors, and prophets. It only takes a slight stimulus to throw them entirely off their balance."
>
> — Clarence Darrow (1932), *The Story of My Life*

Accordingly, before we can engage properly in *human chemical thermodynamics* properly, which, again, is the modern replacement and upgrade to the above summarized 'heat-as-god' logic, we must digress, again, in what seems to be wasted page fluff, on Ancient Egypt.

3.1 | Ancient Egypt

In 3100 BCM, the 20 nomes (states) of Lower Egypt, numbered below, united with the 22 nomes of Upper Egypt to form the first dynasty of Ancient Egypt, comprised of 42 united nomes or territories, each with its own nome god, united by a state capital, originally situated at Heliopolis (#1) aka the city of the sun:

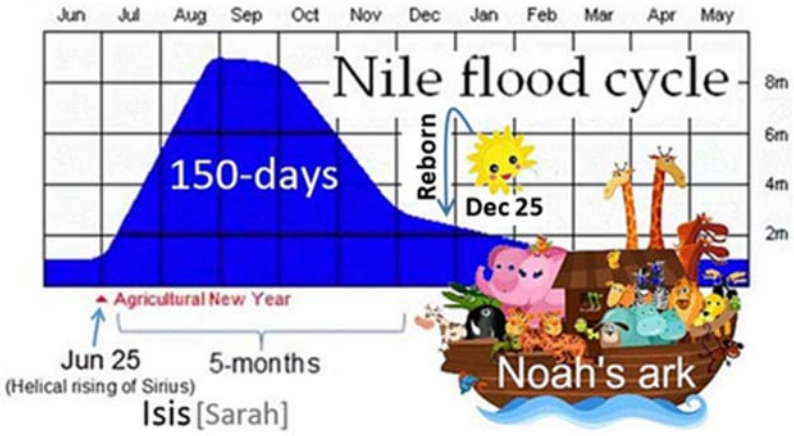


As religio-political power shifted, over time, so too did the state capital, switching from Heliopolis (#1), to Memphis (#2), to Hermopolis (#3), to Thebes (#4), to Amarna (#5), to Sais (#6), each with its own supreme god, e.g. Ra-Atum, or god paut (group), e.g. Ogdoad, all bound by a *henotheism* or supreme god plus lesser gods type of national religion.

In this map, we see, shockingly to some, the origin of many of our most ancient and cherished beliefs, such as: a god (Khnum) creating humans from clay (Adam) and breath (Eve) in Elephantine, Horus (aka Jesus) raising Osiris (aka Lazarus) from the dead, in as depicted on the temple walls at Dendera Temple (30AD), the Hindu god Brahma (aka Ra) being born out of a lotus the stem of which arises from a water god named VishNu (aka Nu), also as depicted on Dendera Temple walls. We see the origin of the 'Christmas Tree' (aka djed pillar) in Busiris, certainly the author was bemused when, two decades ago he learned that Egyptians put evergreen trees in the pyramids. We see the long-outstretched 'fingers of god', aka Aten's sun ray fingers, which, that we are told as children, penned the Biblical ten commandments, as depicted in the temples at Amarna. We see the word 'Amen', aka god Amen, which in 20th century America was said at the end of the Lord's prayer, particular in in Church service, and we see the chief god of Thebes, the myth of the sun being born out of a golden egg, crafted by the god Ptah, in Memphis, among others.

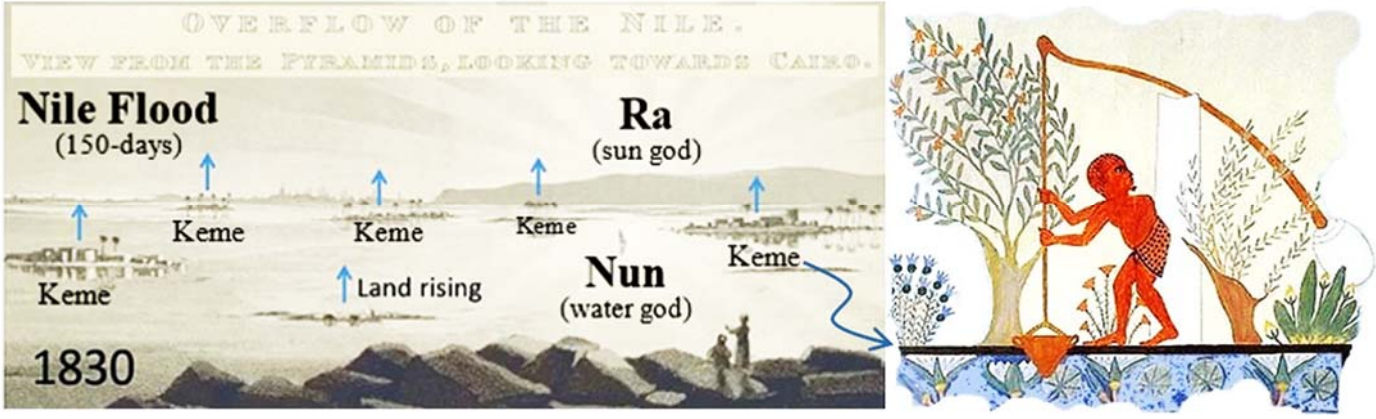
All of these Egyptian god models, are centered around the annual Nile River flood and its correlative astro-theology conceptualized cosmology, the first dominate and longest running version of which being the **Heliopolis creation myth**, promoted in the city of Heliopolis (#1), aka the 'city of the sun', the religious center of Egypt in c.3500 BCM, whereat the sun god Ra was supreme. The Heliopolis creation myth, in short, is based on the following factual data points:

Event #1. On Jun 25, the star Sirius, the brightest star in the sky, previously absent from sight for 70-days, rises, and this so-called **'helical rising'** marks the start of annual Nile River flood, water coming from the melting of snow in the Ethiopian mountains, which lasts on average 150-days, which is EXACTLY the number of days of the length of Noah's flood (Genesis 7:24), waters rising to heights of 30-feet or three stories, submerging entire islands.



Event #2. On Dec 10, as the waters begin to recede, and a black fertile soil called 'keme', the root term of both Egypt and chemistry, is left behind on the banks of the Nile, the so-called Khoiak festival starts, a planting of the grain month, that runs until Jan 8; which, to note, is the forerunner to our modern Christmas season, replete with the raising of an evergreen tree, aka djed pillar, or backbone of the god Osiris reborn as a tamarisk tree, and the Dec 25 rebirth of the sun (in terms of brightness), in the form of the syncretistic sun god Osiris-Ra.

The following, to exemplify, is an image of what the Nile flooding used to look like, for millennia on end, prior to the completion of the Aswan Dam, in nome one, in the year 1970:



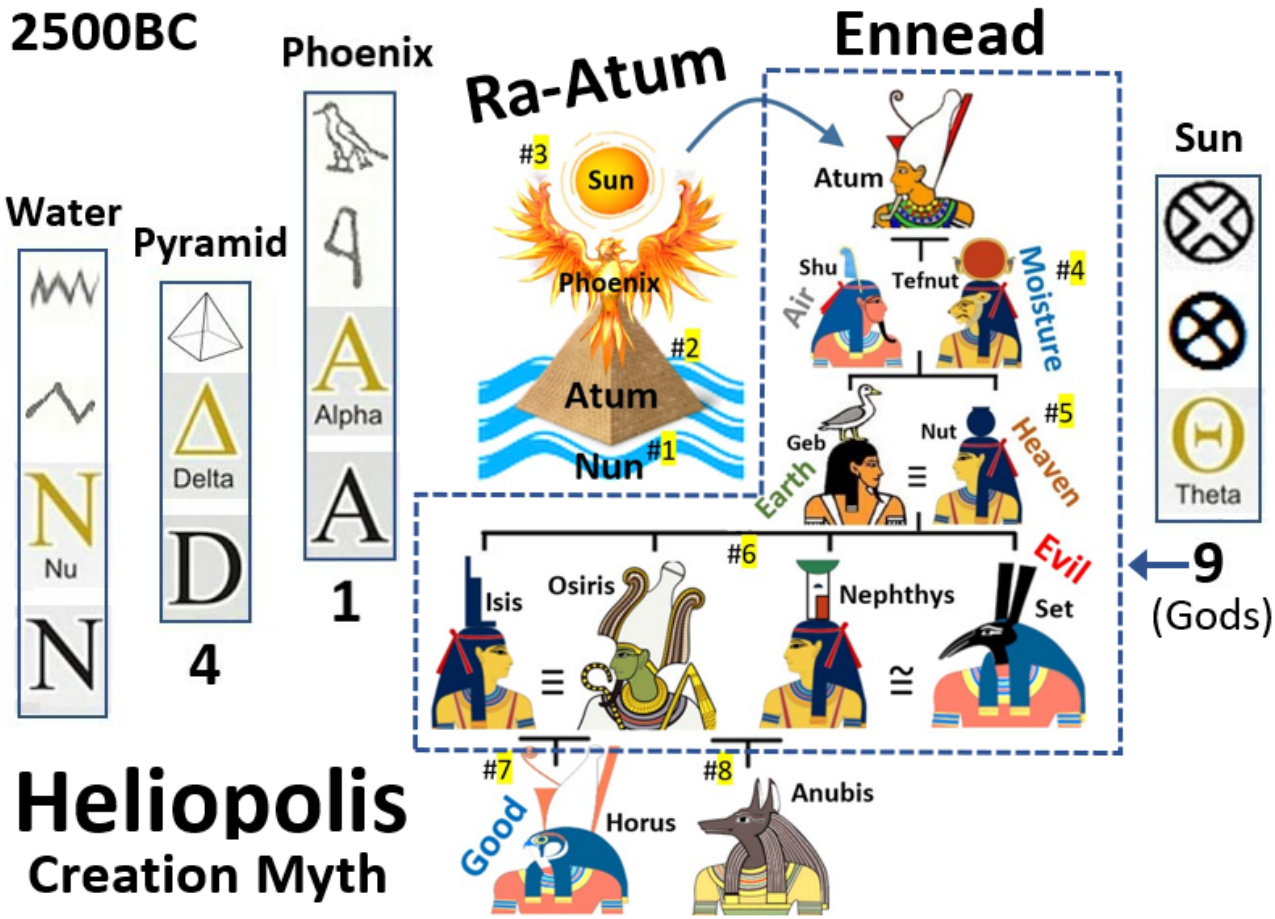
In 2500BC, when the pyramids were being built, the dominate version of the myth of land mound arising out of the water abyss was the Heliopolis creation myth, promulgated in the city of Heliopolis, according to which a land mound, conceptualized as the god **Atum**, arose out of the water abyss, conceptualized as the god **Nun**, out of which simultaneously the sun burst forth, after which the god Atum, now in the form of a man, appeared.

In more detail, the gist of this observable annual flood-star-sun pattern, resulted in a famous creation myth, as formulated in Heliopolis, according to which, prior to the flat earth coming into being, things existed in the form of a flood, water, or a watery abyss, which the Egyptians referred to as the god 'Nun' or Nu, out of which a primordial land mound arose, from which the sun god Atum-Ra burst forth, carried into the sky by the benu bird (aka phoenix), from whose powers he produced the group of nine gods called the Ennead; the following is how it is explained on the walls of the pyramids:

> "To say: O **Atum**-Khepri [**Ra**], when thou didst **mount as a hill**; and didst shine as bnw or benben [bird] in the temple of the 'phoenix' in Heliopolis; and didst spew out as Shu, and did spit out as Tefnut; (then) thou didst put thine arms about them, as the arm(s) of a ka, that thy ka might be in them. Atum, so put thine arms about N; about this temple, about this pyramid, as the arm (s) of a ka; that the ka of N. may be in it, enduring for ever and ever. O Great **Ennead** [9] who are in Heliopolis: Atum, Shu, Tefnut, Geb, Nut, Osiris, Isis, Set, Nephthys."
>
> — Anon (c.2500BC), *Pyramid Text* (Utterance 600)

Here, we will recall that this ‘Ennead’, or group of nine [9] gods, born from the sun god [Ra], is where, as we have shown, the Greek letter Theta ‘Θ’ arose, as employed by Maxwell in referring to science of thermodynamics as ‘ΘΔ’.

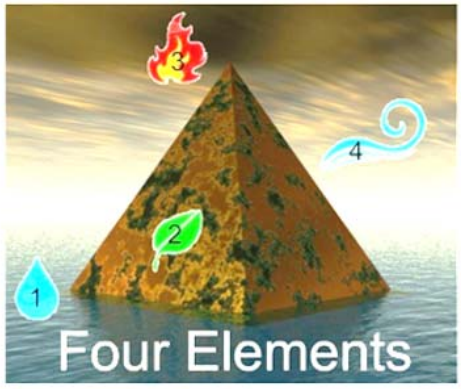
The following diagram, so to bring all of this previously introduced alphabet and number etymology introductory discussion full circle, is the basic model of the famous **Heliopolis creation myth**:



This Ra-Atum based Ennead creation myth, and surrounding mythology, before and after, up to the present-day religious beliefs, to note, takes a minimum of ten years of rigorous study, inclusive of ‘unlearning’ what one was previously taught, culturally, to get a beginner’s level understanding of this diagram.

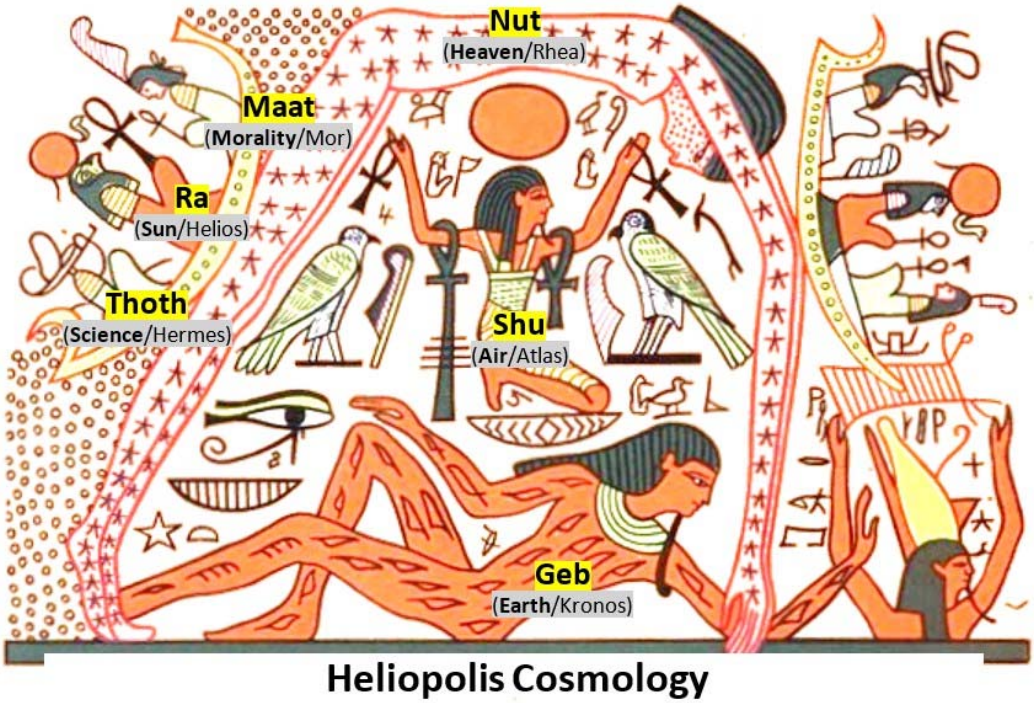
The god Atum, to continue, originally a local god of Heliopolis, arose, of this primordial earth-covering flood, either in the form of the primeval land mound, out of which the sun burst forth, in the form of the benu bird, or phoenix, as Herodotus (450BC), or in the form of a human standing on the primordial land mound, who summoned for the sun, or something to this effect, depending on the two alternative versions of the myth that exist. Atum, as the new main creator god, made four generations of offspring gods and goddess. In short, this utterance 600, states that Atum, described here as the syncretistic god Atum-Khepri, i.e. the sun gods Atum and Khepri joined into one new supreme god, breathed out two more gods, **Shu** or ‘air’ and **Tefnut** or ‘moisture’.

Alternatively, to note, according to Pyramid Text Utterance 527, an alternative version of the myth states that the creation of Shu and Tefnut is described such that 'Atum took his phallus in his grip and ejaculated through it to produce Shu and Tefnut'. This is an example of myth parallelism, often seen in Egyptian mythology, meaning that two alternative theories are incorporated into the text, thought of as two different hypothetical points of view. This myth parallelism was carried directly through into the penning of the creation myth of the Bible, of which two creation myths, Creation Version A and Creation Version B, as found on the Nesi-Amsu Papyrus (310BC), are told in parallel, not to mention that we can read Ovid's *Metamorphosis* (8AD), which can be considered Version C, of the same general original model.[2]



At this point, in the history of human thought, we have the basics of '**four element theory**', at least in its proto-conceptual god-based framework, the origination of all things in terms of earth, air, water, and fire, as illustrated adjacent (right).

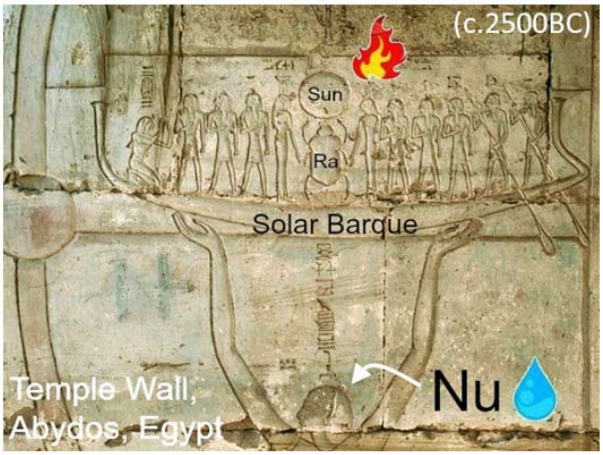
Next, according to Heliopolis creation myth, the gods Shu (air) and Tefnut (moisture) divinely procreated the gods **Geb** (earth) and **Nut** (sky), who were thereafter separated by their father Shu, who is shown below holding them apart; and above which **Ra** the sun god rides in in solar barque, accompanied by the gods **Thoth**, the god of wisdom and science, and **Maat**, the goddess of morality and justice, to be reborn each day:

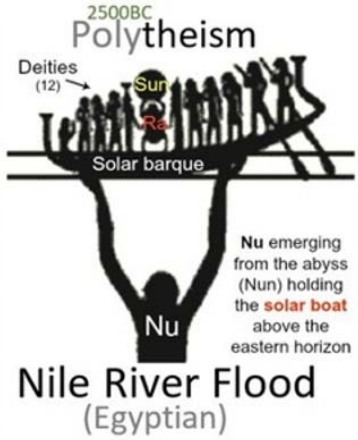


Heliopolis Cosmology

Also shown above, below each god name, is the Greco-Roman god rescript of each Egyptian god, as well as the conceptual 'thing', e.g. sun, earth, heaven, morality, etc., each Egyptian god represented, a model otherwise known as Egyptian cosmology; which, to note, is the forerunner to Aristotelian cosmology, and hence Ptolemaic cosmology, aka an earth or Geb-centric (geo-centric) model of the world. It would not be until the mind of Copernicus, and his *On the Revolutions of the Heavenly Orbs* (1543), that this model would be overthrown.

The following is a c.2500BC artistic representation of either Khepri, Atum-Khepri, or Khepri-Ra, from one of the temple walls in Abydos, Egypt, carrying the sun through the sky on his solar barque:





Next, according to Heliopolis the genesis story, Osiris (Christian rescript: God the Father / Holy Spirit) and Isis (Christian rescript: virgin Mary) then paired to make the god **Horus** (Christian rescript: Jesus).

Next, Nephthys (Christian rescript: Mary Magdalene), who was, as the tale tells, an unwilling partner in marriage to Set (Christian rescript: Satan), tricks Osiris into sleeping with her, via pretending that she was her twin sister Isis, and therein makes **Anubis** (Christian rescript: John the Baptist) the mortuary and baptism god. This genealogy, in this period, was a progressive merger of far older disjunct local mythologies, e.g., in one older version, Anubis was the sun of Ra, and Horus, who battled Set, was the oldest and greatest of all the gods.

In 2100BC, in the era the penning of the Coffin Texts (c.2100BC), the Atum-Khepri supreme god model began to be replaced with a syncretism of the more ancient god Ra, aka the 'father of the gods' (Budge, 1904), whose origin is unknown, into the form of the joint god **Atum-Ra**.

In the Roman era, most of this Heliopolis myth was culturally known in the sense of a crude astro-geo-cosmology; such as summarized below:

> "Who is there that does not know that the **vapor of the Sun** is kindled by the **rising of the dog-star** [**Sirius**]? The most powerful effects are felt on the earth from this star. "When it rises, the seas are troubled, the wines in our cellars ferment, and **stagnant waters** [**Nile**] **are set in motion**. There is a wild beast, named by the Egyptians Oryx, which, when the star rises, is said to stand opposite to it, to look steadfastly at it, and then to sneeze, as if it were worshiping it. There is no doubt that dogs, during the whole of this period, are peculiarly disposed to become rabid."
>
> — Pliny the elder (77AD), "On the Rising of the Dog Star"

Naturalistically speaking, Romans, in this period, and presumably Greeks and Egyptians prior, believed that when Sirius rose, on Jun 25, the flame of the sun began to rekindle, and this somehow triggered the start of the Nile River flood. Over time, going forward, the structure of the myth changed, as religious power centers shifted from Heliopolis, to Memphis, to Hermopolis, to Thebes, to Amarna, to Jerusalem, to the Middle East, as follows:[9]

0. Pre-Dynastic creation myth | 3500BC | Supreme god: Horus
    1. **Heliopolis creation myth** | 3100BC | Supreme god: **Atum-Ra** / Ennead
    2. Memphis creation myth | 2800BC | Supreme god: Ptah
        3. Hermopolis creation myth | 2400 BC | Supreme god: Ogdoad
            4. Thebian creation myth | 2050 BC | Supreme god: Amen
            5. Amarnan creation myth | 1300BC | Supreme god: Aten
                6. Second Theban recension | 1150BC | Supreme god: **Osiris-Ra**
                7. Saite recension | 670BC | *Book of Dead* (canonized)
                8. Biblical creation myth | 500BC | Supreme god: El-Yahweh-Amen
                9. Muslim creation myth | 700AD | Supreme god: Allah

The core dominate strand of all of these myths, regardless of reformulation, was that Nu was a water god who carried Ra as a sun god on his solar barque though his daily journey through the sky.

3.2 | Hindu and Judeo-Christian-Islamic Rescripts

The Egyptian Ra born out of Nu, or Ra carried by Nu, following the rising of Sirius, motif or model, over time, via the methods of cultural migration, wars, study abroad education programs, and trade route based information exchange, became rescripted, cross-culturally, as follows:

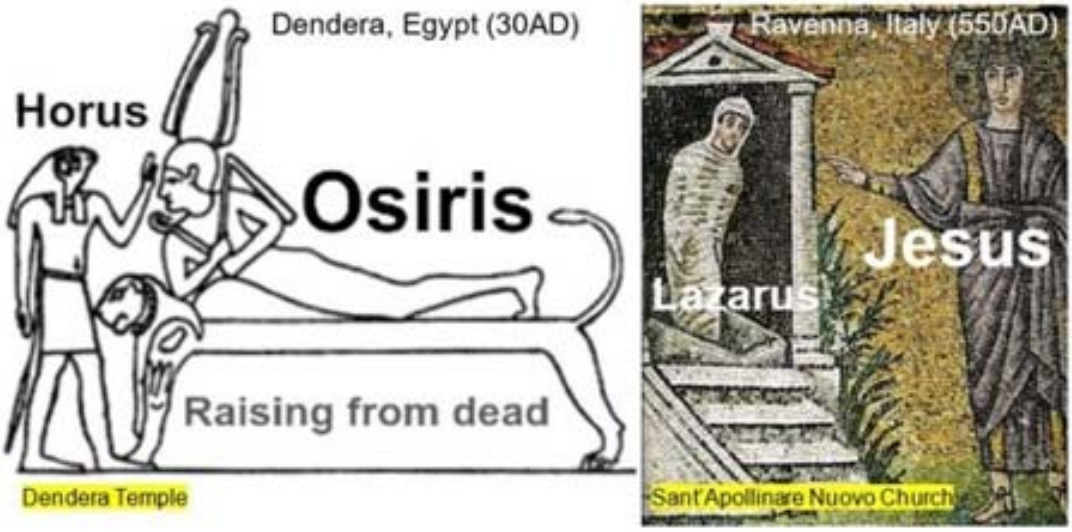
	Ra Rescripts	Nu Rescripts	Sirius Rescript
Hindu (900BC)	B**ra**hma	Ma**Nu**	**Sara**swati
Judeo-Christian (300BC)	Ab**ra**ham	**Noah**	**Sara**h
Islam (600AD)	Ib**ra**him	**Nu**h	**Sara**

Intermixed with this Ra-Nu sun rebirth motif was the famous so-called myth of the death and resurrection of Osiris, which is based on the annual rising of the Orion constellation, which occurs nightly in late Nov to Dec, wherein the human figure like Orion constellation of stars appears to be rising from the dead, such as shown below at three time intervals on Dec 24:

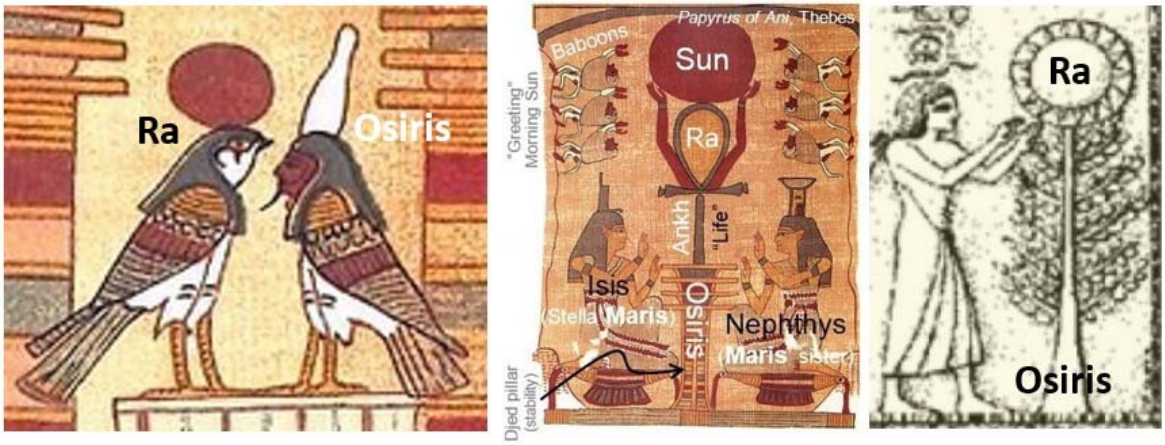
This annual observable raising of the Orion constellation became the motif for c.2800BC myth of the death and resurrection of Osiris, as shown below:

This model, when spread culturally, became the prototype for all dying and rising gods, historically, in the form of what are called Osiris rescripts.[3]

In 30AD, a variant of the Osiris resurrection myth was being told, wherein the god Horus, the son of Osiris, raises his father from the dead, such as shown below, left, as carved onto the walls of Dendera Temple. By 550AD, this Horus raising Osiris model had been monotheistically recast into the myth of Jesus (aka god Horus) raising the mummy Lazarus (i.e. El Osiris) from the dead, as shown on the walls Saint Apollinare Nuovo Church, Ravenna, below right:[4]



In 1250 to 1150BC, in Thebes, the so-called 'second Theban recension' occurred resulting in Osiris and Ra becoming reconceptualized as equal in supreme god power, in the form of the joint god Osiris-Ra, wherein the annual Dec 25 rebirth of the sun and the Nov-Dec rising of Orion constellation, as shown above, were rescripted to the affect that the sun or sun god Ra was said to be born out of the djed pillar or backbone of the god Osiris, resurrected in the form of an evergreen tree (tamarisk tree), as shown below:



The gist of this myth, which is from where the modern Christmas tree with a star (or angel with sun disc halo) at the top originated, is recounted as follows:[5]

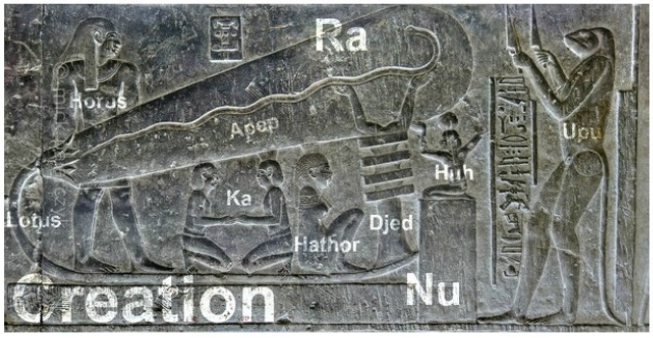
> "Myths told how the [bennu/phoenix] bird [bird that carried the newborn sun on its head] was born from the midst of flames which **arose from out of the summit of a tree** in Heliopolis, and that it was known to men by the beauty of its song, to which even the sun himself love to listen. The phoenix symbolized the morning sun arising out of that fiery glow of dawn which dies away as the new born luminary ascends the sky, and hence was regarded as the bird of Ra. But since the dead sun was held to become an Osiris and the new sun to arise from the embalmed body of the old which had been duly brought to Heliopolis, in like manner also the phoenix was supposed to be a form of Osiris in which the god returned to his own country."
>
> — Alfred Wiedemann (1897), *Religion of the Ancient Egyptians*

As this Egyptian astro-theology was carried into neighboring cultures, the sun god Ra became: the Hindu god Brahma (c.900BC), the Judeo-Christian prophet Abraham (c.300BC), and the Islam prophet Ibrahim (c.600AD); the water god Nu became: the Hindu man MaNu and or the god VishNu (900BC), depending, the Judeo-Christian man Noah (c.300BC), and the Islamic prophet Nuh (600AD); and god Osiris (as Orion) became the Jewish lawgiver Moses as well as the Christian dying and rising god Jesus. A synopsis of these 'physical things' (river, star, sun, etc.) to 'god' to 'prophet' rescripts are tabulated below, for the five main theologies:

	Egyptian (3100BC)	Hindu (800BC)	Jewish (300BC)	Christian (300AD)	Muslim (700AD)
Nile	Nun	VishNu / MaNu	Noah	Noah	Nuh
Earth	Atum	Atman / Adimo	Adam	Adam	Adam
Milky Way	Hathor		Eve	Eve	Hawa
Sun	**Ra**	**Brahma**	Abraham	Abraham	Ibrahim
Sirius	Isis	Saraswati	Sarah	Sarah / Mary	Sara / Maryam
Orion	Osiris	Krishna	**Moses**	**Jesus**	Musa

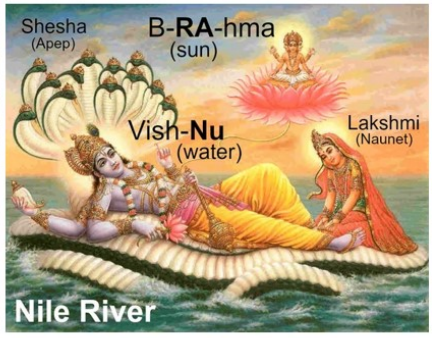
The gist of Egyptian to Hindu myth rescript is shown below, wherein the sun god Ra is depicted, below left, as a bulb of sun light coming out of a lotus (the stem of which dipping into the water god Nu), becomes the Hindu creator god Brahma (the stem of which comes from the navel of the water god VishNu):[6]

Dendera Temple | 40AD



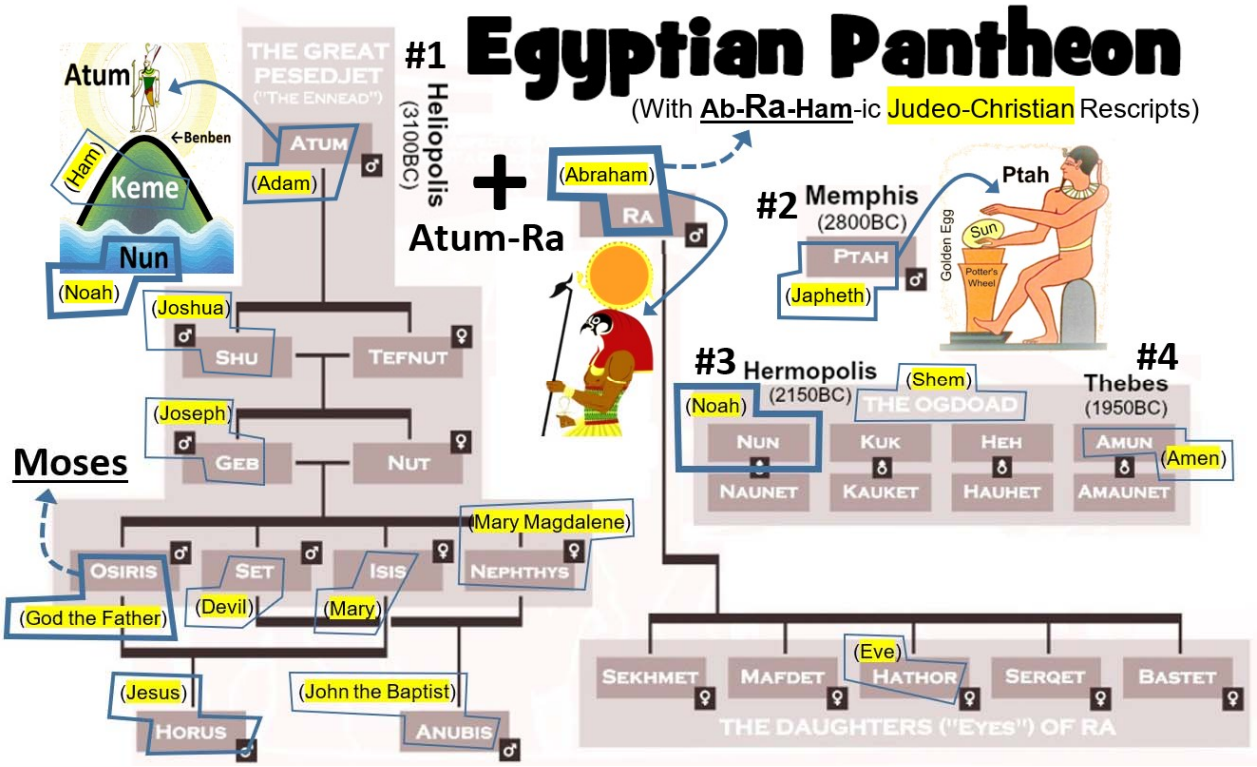
Egyptian Creation Myth
(Original)

Bhagavata Purana | 800AD



Hindu Creation Myth
(Re-Script)

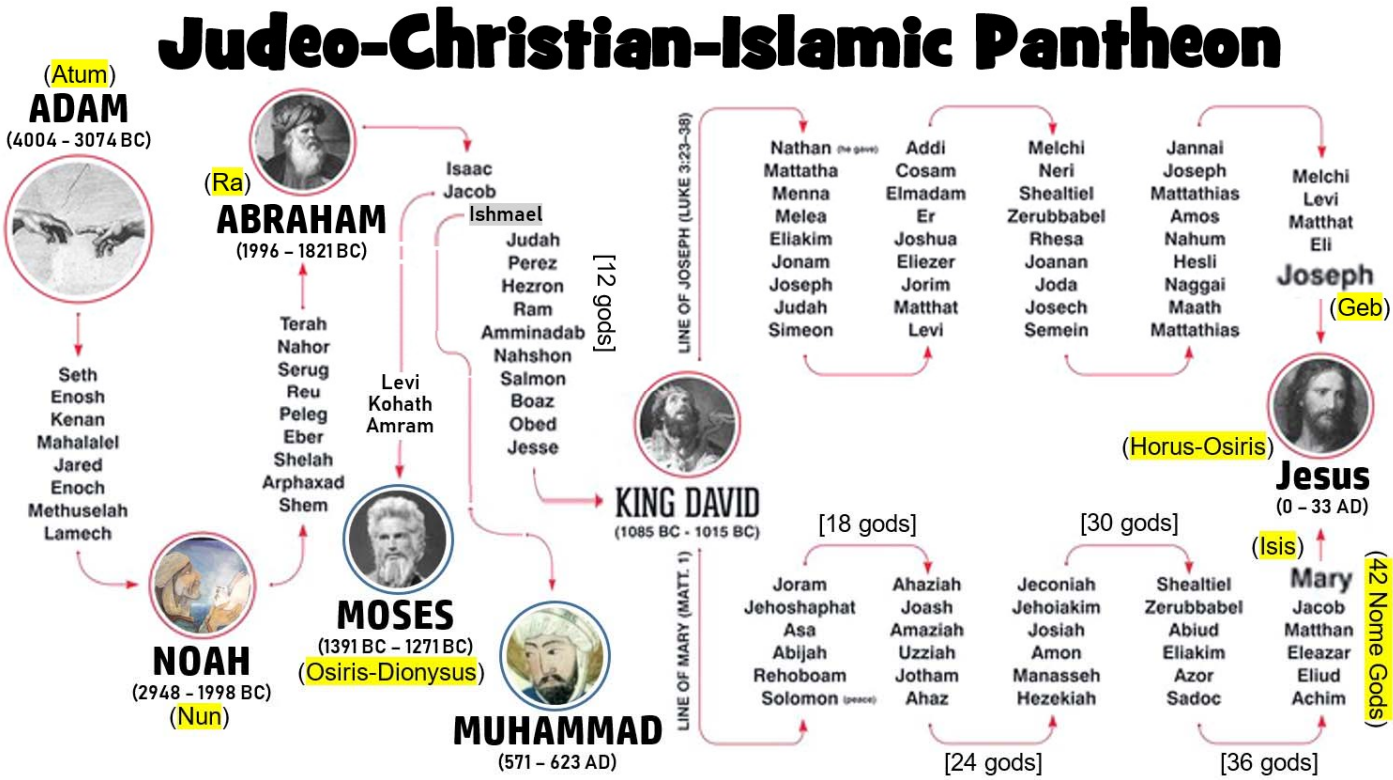
The main rescripts of the Egyptian to Judeo-Christian-Islamic myth is shown below, wherein to make a monotheism out of a polytheism, the 'Hebrews turned gods into Patriarchs' (Dunlap, 1858), aka they effected a god-to-prophet rescript:



In short, the god Atum became the man Adam, the goddess Hathor became Eve, the water god Nun became the man Noah, the sun god Ra became the man Abraham, Ptah becomes the man Japheth (one of the three sons of Noah), Shu becomes the man Joshua (son of Nun; Moses' aid), Geb becomes the man Joseph (step-father of Jesus) the syncretistic god Osiris-Dionysus became the lawgiver Moses, Osiris becomes god the father and the holy spirit, Set becomes the Satan (or the devil), the goddess Isis becomes the virgin mother Mary.

Moreover, Nephthys becomes Mary Magdalene, the syncretistic god Osiris-Horus becomes Jesus, the god Anubis, cousin of Horus, became the John the Baptist, cousin of Jesus, and the 42 nome gods that sat in attendance in the afterlife Judgment Hall, during the weighting of the soul, between Ra and Osiris, became the 42 generations (men) between Abraham and Jesus. Last, but not least, the polymorphous god Amun (the gods Nun, Ra, Ptah, and Atum incarnate), becomes rescripted as the word said at the end of prayers, all amalgamated together into a sort of Shrek-like aggregate of all the main classic fairy tales or creation myths, the numbers (1-4) indicating when the supreme god reformulations or recensions of the Egyptian state religion took place, the first being when in Heliopolis the ancient god Ra and the local god Atum were syncretized into the joint god Atum-Ra:

Next, in c.700AD, Islamic theologians would, in the same god-to-prophet reduction tradition, claim a lineage from Abraham to Muhammad via an invented son Ishmael, substantiating the myth via a story that Muhammad visited all the previous 'prophets', e.g. Moses, Abraham, Noah, and Adam, in his famous night journey while riding on a flying donkey (buraq):[7]



The online 'god character rescripts' table goes through, in fuller detail, the god character equivalents, from Egyptian, to Sumerian, Akkadian, Babylonian, Assyrian, Indian, Persian, Greek, Roman, Hebrew, Christian, Germanic, and Muslim.[8] The online 'Osiris rescripts' and 'supreme god timeline' tables should be consulted as well to better understand the above.[9] The subject of religio-mythology decoding is an evolved one, to say the least.

Those new to the subject of religio-mythology and astro-theology, much of the above is still very prevalent in the modern cultural milieu, as real beliefs, e.g. prior to 2003 the author actually believed, in some naive sense, that Abraham was a real person, and would spend days in Barnes & Noble reading trying to figure out who he was; accordingly, much time and reworking of the mind will be required to *unlearn* much of the above mythology.

> "Fables should be taught as fables, myths as myths, and miracles as poetic fancies. To teach superstitions as truth is a most terrible thing. The **child mind accepts and believes them**, and only

> through great pain and perhaps tragedy can he or she be in after years relieved of them. The reason for this is that a superstition is so intangible a thing that you cannot get at it to refute it."
>
> — Hypatia (c.400 ACM), *Publication*

The inquisitive reader is encouraged to read through the works of the top 155+ religio-mythology scholars who have made the above decoding possible.[10]

Synopsis: (add)

References

1. http://www.eoht.info/page/Finger+of+god
2. www.eoht.info/page/Genesis
3. http://www.eoht.info/page/Osiris+rescripts
4. http://www.eoht.info/page/Raising+of+Lazarus
5. http://www.eoht.info/page/Christmas+Tree
6. http://www.eoht.info/page/Brahma
7. http://www.eoht.info/page/Judeo-Christian+pantheon
8. http://www.eoht.info/page/God+character+rescripts
9. (a) http://www.eoht.info/page/Osiris+rescripts
(b) http://www.eoht.info/page/Supreme+god+timeline
10. http://www.eoht.info/page/Religio-mythology+scholars
11.

4. Four Elements, Atoms, and Void

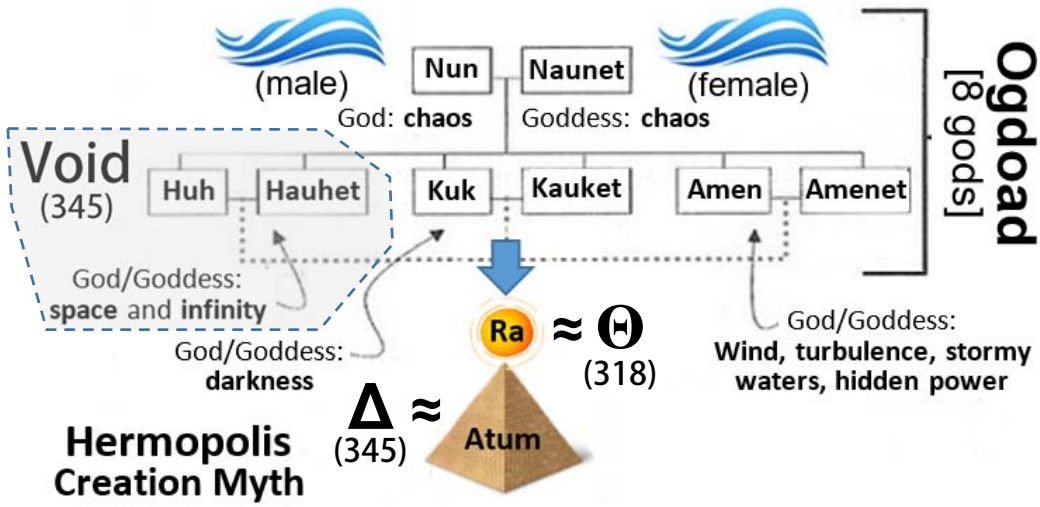
> "Greeks, thirsting for knowledge, sought the Egyptian priests for instruction. Thales, Pythagoras, Oenopides, Plato, Democritus, Eudoxus, all visited the land of the pyramids. **Egyptian ideas were thus transplanted across the sea** and there stimulated Greek thought, directed it into new lines, and gave to it a basis to work upon."
>
> — Florian Cajori (1991), *A History of Mathematics*

Chapter point: to outlined the Greek model of things, with focus on their views in respect to existence or non-existence of the void [length: 4-pgs]

In c.850BC, the Greeks, beginning with Lycurgus, followed by Orpheus, Solon, Thales, Pythagoras, Empedocles, Herodotus, Democritus, Plato, Eudoxus, and Manetho, travelled to Egypt, via the study abroad method, to learn Egyptian cosmology, and to therein, over time, convert their god-based element origin of things, into a proto-scientific water, earth, fire, air model of things.[1] Thales, foremost among this group, during his travels in Egypt, measured the height of a pyramid and to have introduced geometry into Greece from his studies in Egypt. The key concept Thales took away from his studied in Egypt was the model that the universe originally existed in the state of a watery abyss, called the Nun, and that from this, the other three elements are derived.

> "The Egyptian myth, of Atum rising from the Nun, i.e. of an earthen hill rising from the water chaos, **matches Thales' world portrait** better than anything gathered from the disjunctive mythology of Greece."
>
> — Karl Luckert (1991), *Egyptian Light and Hebrew Fire* (pg. 199)

Anaximander, Thales' immediate student, likewise thought to have travelled to Egypt, and he is thought to have expanded on his mentor's philosophy, by focusing not on the water aspect of the Nun, but on the void or infinity aspect of Nun, such as found in the space or void god Huh of the Hermopolis recension of the creation myth, as shown below:



This so-called 'Hermopolis creation model', as is generally understood, such as speculated by Aristotle (*Physics*, 320BC), is from where Hesiod, in his *Theogony* (700BC), derived his model of the god Chaos (void), creating Gaea (earth) and Uranus (sky) origin of things, which he conceived as a void or gap. Anaximander would have known both models. Anaximander summarizes his version of the origin of things as follows, wherein the 'apeiron' is what he conceptualizes as the infinite void or boundary without form, from which all things arise:

> "It is neither water nor any other one of the things called elements, but the infinite [*apeiron*] is something of a different nature, from which came all the heavens and the worlds in them. And from

> what source they arise, to that they return of necessity when they are destroyed; for they suffer punishment and make reparation to one another for their injustice according to the order of time."
>
> — Anaximander (c.545BC), *Publication*[2]

In 530BC, Pythagoras, in alignment with Anaximander, employed the notion of non-being or void as the original chaos or dark abyss from which things; he is said to have argued the following:

> "I assert the **existence of the void**, and hold that it enters the heavens from the unlimited breath, so breathing the void, which demarcates natural things, forming a void space or distinction between things which are in succession. It is this void which distinguishes their nature. Outside the cosmos there is a void, into and out of which the cosmos breaths."

In 520BC, Xenophanes, employing Anaximander's apeiron model, stated things thusly:

> "The upper limit of earth borders on air. The lower limit reaches down to the unlimited, i.e. the apeiron."

Xenophanes, in turn, is said to have influenced Heraclitus, the flux and fire based being and becoming philosopher, and Parmenides, the being and void-denying philosopher. Parmenides, in turn, influenced, Empedocles.

In 455BC, Empedocles, in his *On Nature and Purifications*, gives either of four or five element account of things according to which the order of generation goes, depending on fragment and interpretation, as follows:

> "The strength of the aether pursues him [the daemon] into the **sea**, and the sea spits him onto the surface of the **earth**, and the earth into the beams of the blazing sun, and it throws him into the eddies of the **air**."
>
> — Empedocles (c.455BC), Fragment I11 / DK 115

Here, we have the general order: sea (root #1), earth (root #2), sun (root #3), air (root #4), and ether (root #5), give or take debates on whether or not Empedocles considered either as an actual root. Another fragment, which gives a different generation of roots order, reads as follows:

> "First, hear the 'four roots' of all things, gleaming Zeus [Sun/Lightening] and life-bringing Hera [Air/Earth] and Aidoneus [Air or Earth], and Nestis [water], who moistens with tears the spring of mortals."
>
> — Empedocles (c.455BC), Fragment I12 / DK 6

The earliest contemporary account of this generation of roots process, which cites Empedocles as referring to ether as the first root, reads as follows:

> "Empedocles says that aether was separated off first, and fire second, after which came earth, from which, as it was squeezed about by the force of the rotation, water gushed out. From the water, air was vaporized and the heaven came into being from the aether, and the sun from the fire, and the things around the earth were condensed from the others."
>
> — Aetius (c.125AD), *Publication* (2.6.3)

In 420BC, Democritus, after studying in Egypt or five years, and supposedly everywhere else for that matter, would boast that he was one the smartest men on the planet, at least in respect to geometry:

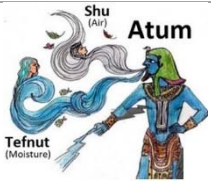
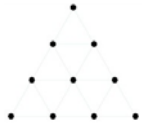
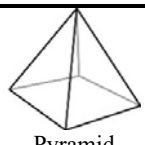
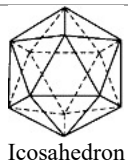
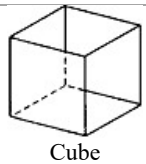
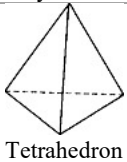
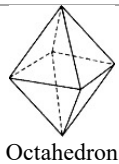
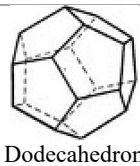
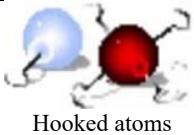
> "Among all my contemporaries, I have travelled over the largest portion of the earth in search of things the most remote, and have seen the most climates and countries, heard the largest number of thinkers, and no one has excelled me in geometric construction and demonstration—not even the geometers of **the Egyptians, with whom I spent in all five years as a guest**."
>
> — Democritus (c.420BC), Fragment #; cited by Friedrich Lange (1865) in *History of Materialism, Volume One* (pg. 17)

In this period, he developed, based on part of his studies of Leucippus and likely from the Hermopolis creation model of the Egyptians, a theory arguing that the universe is comprised of things he called 'atoms', from the Greek *atomos* meaning 'uncuttable'; the following being the standardly accepted etymology of the term:

"It is called the 'atom' not because it is the smallest thing, but because it **cannot be cut**, since it cannot be affected and contains no void."

— Eusebius (c.313), *Praeparatio Evangelica* (XIV.14.5)

The following, to summarize, are the various derived methodologies, according to which each philosopher transformed the Egyptian god-based four element theory into a proto-scientific theory of the first principles or basic stuff of things (those show with an E superscript are definitively known to have travelled to study abroad in Egypt), the main god of each element shown as well:[3]

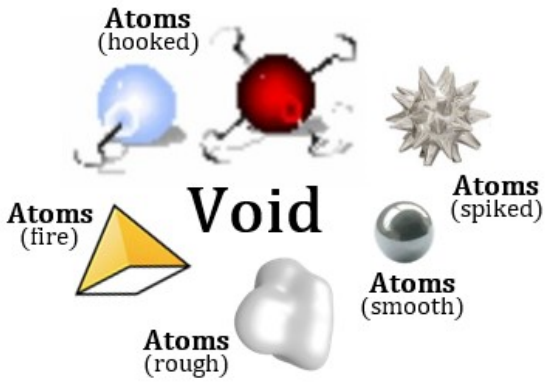
	Water	Earth	Fire	Air	Other
Heliopolitans (2600BC)	[Nun]	[Atum]	[Ra]	 [Shu]	
Hermopoleans (2400BC)	[Ogdoad]	[Atum]	[Ra]	[Shu]	
Hesiod (700BC)	[Chaos]	[Gaia]			
Thales (580BC)[E]	**Primary matter**				
Anaximander (570BC)	**Primary matter**				**Apeiron**
Anaximenes (545BC)				**Primary matter**	
Pherecydes (540BC)		Primary matter			
Pythagoras (530BC)[E]	Derived	Derived	 Tetractys	Derived	**Monad** / Yes Void
Xenophanes (520BC)	Primary matter	Primary matter			**Apeiron**
Heraclitus (495BC)	Secondary matter	Secondary matter	**Primary matter**		
Parmenides (470BC)			Primary matter	Primary matter	**Being**
Leucippus (460BC)					**Atoms & Void**
Anaxagoras (460BC)					Ether / No Void
Empedocles (455BC)[E]	**Root 1**	**Root 2**	**Root 3**	**Root 4** (ether: root 5)	Love and Strive (no emptiness)
Democritus (420BC)[E]			 Pyramid		Atoms & Void
Plato (385BC)[E]	 Icosahedron	 Cube	 Tetrahedron	 Octahedron	 Dodecahedron
Aristotle (340BC)	Primary	Primary	Primary	Primary	**Ether** / Teleology
Epicurus (300BC)					**Atoms** & Void
Lucretius (55BC)	Round atoms	 Hooked atoms	Pointed / Tiny atoms		Atoms & Void

The term ‘atom’, as some, e.g. Rene Lubicz (1948), have conjectured, could possibly be etymologically related to the Egyptian land god Atum.[4] Likewise, the term ‘void’, meaning empty space, derived either from Hesiod’s Chaos model, as Aristotle conjectures, or from of the Egyptian void god Huh of the Hermopolis creation model, which he would have learned in Egypt.

In c.300BC, Epicurus, likewise, after being taught as a youth Hesiod’s Egyptian based creation model, became dissatisfied with the underlying explanation of chaos, and so therein sought out void based atomic theory as an upgraded solution:

> “Apollodorus, the Epicurean, in the first book of his Life of Epicurus, says that Epicurus turned to philosophy in disgust at the schoolmasters **who could not tell him the meaning of ‘chaos’ in Hesiod**. According to Hermippus, however, he started as a schoolmaster, but on coming across the works of Democritus turned eagerly to philosophy.”
>
> — Diogenes Laertius (c.230AD), Lives and Opinions of Eminent Philosophers (§:X.1)

Shown adjacent, is an overview of Democritus-Epicurean model of ‘atoms and voids’ being the nature of the structure of the universe, according to which there existed different types of atoms: hooked, spiked, smooth, rough, pyramid-shaped, and so on, that existed in a void of space, from which all things derived.



Empedocles and Democritus, in particular, would go on to dominate the mind of Aristotle, who in turn dominated the mind of humanity for the next two millennia; dominate, that is, until some, in the 16th century, e.g. Jean Fernel (1548), began to take a stand and question some of the basic tenets of Aristotelianism.

Intermixed in all of this, as discussed in the next chapter, is Parmenides’ denial of the void and later Otto Guericke’s 1647 to 1663 attempts to demonstratively make a void, which is the starting point of the derivation of the equations of thermodynamics.

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1. http://www.eoht.info/page/Egypt
2. Luckhert, Karl. (1991). *Egyptian Light and Hebrew Fire: Theological and Philosophical Roots of Christendom in Evolutionary Perspective* (pgs. 199-200). SUNY Press.
3. http://www.eoht.info/page/God+character+rescripts
4. http://www.eoht.info/page/Atoms+and+Atum
5.

5. Parmenides (470BC)

> "Parmenides' theory may be described as the first hypothetico-deductive theory of the world. The atomists took it as such; and they asserted that it was refined by experience, since motion *does* exist. Accepting the formal validity of Parmenides' argument, they inferred from the falsity of his conclusion the falsity of his premise. But this meant that the **nothing** — the **void**, or empty **space** — existed. Consequently, there was now no need to assume that 'what is' — the full, that which fills some space — had no parts; for its parts could now be separated by the void."
>
> — Author (1958), "Back to the Presocratics"

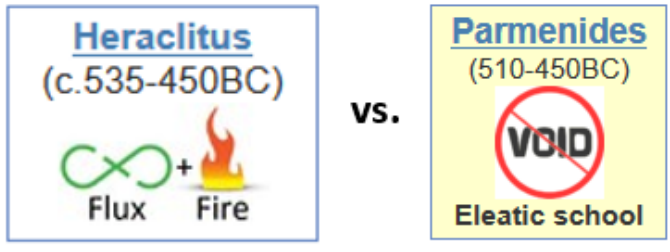
Chapter point: Give overview to the philosophically-confused supposition that a void, vacuum, or empty space cannot exist, is an impossibility, and or an abhorrence to nature [length: 4-pgs].

In 495 BCM, **Heraclitus**, a Greek philosopher, commonly known as the 'flux and fire' philosopher, the 'riddler', as the Stoics called him, or the 'murky', in his now-lost *On Nature*, following his education in Egypt, posited that *fire* is the primary element, and from fire, the secondary elements *water* and *earth* are derived; the following is a preserved fragment of his logic:

> "The universe, that is the all, is made neither of gods nor men, but ever has been and ever will be an eternal living fire, kindling and extinguishing in destined measure."
>
> — Heraclitus (c.495BC), *On Nature*

In his scheme, these three elements, fire, earth, and water, supposedly, are presumed, according to historical consensus, although only few extant fragments of his work exist, to be embedded in some type of 'void', the operation of which accrues according to which there exists a universal tension, which ensures that 'change' is continual, that everything is in a state of flux, whereby permanence does not exist in the universe, only the permanent condition is that of 'change', as a result of the transformations of fire, or an admixture of flux and fire.

The unwritten logic of this Heraclitean argument is that the 'being' of things, think human *being* here, and the concordant idea of 'being' and 'becoming', is always in a continual state of change, towards becoming something new. Heraclitus, accordingly, in his philosophy, denied the reality of an 'unchanging being', and is retrospectively classified as a 'being and becoming' philosopher. The go-to example of being and becoming, in human chemical thermodynamics, as will be discussed, is the scenario of the Captain, of Goethe's *Elective Affinities* (1809), 'becoming' a Major, and therein being able to respectively to marry Charlotte, owing to the social standing of his new being.



In 470 BCM, **Parmenides**, a Greek philosopher, characterized a 'monistic materialist', similar to Heraclitus, albeit divergent in views, published a rather peculiar argument, classically understood as an attack on Heraclitus, which some have called the most 'paradoxical and absurd metaphysical arguments in the history of philosophy', in defense of what might be called *continuity of being*, the gist of which, is that a 'void', and concordantly 'motion', are impossible, per logic that if a void existed, then 'being' could, theoretically, go into 'non-being', which is an 'absolute impossibility', according to Parmenides. The following are fragments of Parmenides' argument:[1]

> "Therefore, must it either be altogether or be not at all. Nor will the force of truth suffer ought to arise besides itself from that which is not. Wherefore justice doth not lose her fetters and **let anything come into being or pass away, but holds it fast**. Our judgement thereon depends on this: 'It is or is it not?' Surely it is adjudged, as it needs must be, that we are to set aside the one way as unthinkable and

nameless (for it is no true way) and that the other path is real and true. How, then, can what is be going to be in the future? Or how could it come into being? If it came into being, it is not; nor is it if it is going to be in the future. Thus, is **becoming extinguished and passing away are not to be heard of**."

— Parmenides (c.470BC), *The Way of Truth* (fragment 8)

Said another way:

"**Being is unbegotten, indestructible**, whole, eternally one, immovable and infinite. With it there is no was nor shall be; the whole is forever now, one and continuous."

— Parmenides (c.470BC), *Fragment*; cited by: Henry Bray (1910) in *The Living Universe* (pg. 251)

Parmenides, in sort, believed in one and only one unchanging and immovable 'being'. As movement and change, accordingly, would require a 'void' to operate, the nature of which would allow for *un-being*, he denied both, along with birth and death. The paucity of extant Parmenides fragments and commentary on his views leaves the mind wanting for elaboration; the following, however, seems to capture the gist of what Parmenides was so-strongly arguing about:[7]

The presumed reality of motion, birth, change, and death, according to Parmenides, are illusions, they do not exist. Parmenides, according to another interpretation, was arguing that it is impossible to form a concept of *no-thing-ness* or 'non-being', which is what belief in the void amounted to.[3] There is, to note, supposedly, an ongoing controversy, as fragments are lacking detail, as to whether Parmenides was consciously attempting to refute Heraclitus; the fragments available, however, are too limited to be able to summarize the matter conclusively. The reader is encouraged to peruse the online Greek philosophy tree, showing the top 70 Greek philosophers, and how the influences of Heraclitus and Parmenides played out in respect to influence, wherein we see that Zeno of Elea, Melissus, and Empedocles were the main absorbers of Parmenides no-void theory, and that the former two influenced and or mentored Leucippus, who in turn taught Democritus, the famous leader of atomic theory:[4]

In 455BC, Zeno of Elea, Parmenides' first main student, defended the views of Parmenides, including supposedly his belief in denial of the void, in the Athenian tribunal, in the presence of Socrates.[5] Also, that year, give or take, Empedocles, Parmenides second main student, likewise professed a modified reformulation of his mentor's void-denying model

"The **universe has no space that is empty** nor space that is overcrowded."

— Empedocles (c.455BC), Fragment I19 / DK13

Empedocles, here, similar to Parmenides, seems to deny the void per reason that he finds it inconceivable that being could come out of non-being:

> "It is **impossible that there should be coming to be from what is not** [void], and that what is [as being] should be destroyed, is unaccomplishable and unheard of; for it will always be there, wherever one may push it on any occasion."
>
> — Empedocles (c.455BC), Fragment I18 / DK12

Empedocles would later state as a matter of fact, according to Theophrastus (*De Sensibus*, c.340BC), that 'there is absolutely no void'. The extant fragments of Empedocles, however, to note, are not this explicit.

In 430 BCM, Melissus, Parmenides' third main student, continued with Parmenides' anti-void argument, based on denial of non-being, with explicit void denial:[2]

> "**There is absolutely NO void**. For void is not-being and the nothing could not exist. And it does not move. For it cannot move in any direction. But it is full. For if there were void, it would move into that void, but since there is no void it has nothing to move into."
>
> — Melissus (c.430BC), *Fragment*

Zeno and Melissus both, in turn, taught or influenced Leucippus, the purported inventor of atoms and atomic theory, who in turn taught Democritus, the presumed intellectual father of Epicurus. The latter two, Democritus and Leucippus, however, broke with the void-denying philosophy of the latter, Zeno and Melissus.

> "The 'plenum' [space with atoms] and 'void' [space without atoms], according to Democritus, exist, the one as '**being**', the other as '**not being**'."
>
> — Aristotle (350BC), *Physics* (§1.4)

Specifically, in 460BC, Leucippus, followed by Democritus, in 420BC, decided that the way to solve the impasse was to accept the existence of the void; this new void-*accepting* philosophy is summarized as following:

> "Leucippus associated in philosophy with Parmenides, but did not follow the same path as Parmenides and Xenophanes about what there is, but, it seems, the opposite. For they, Parmenides and Xenophanes, made the universe consist of one changeless, ungenerated, and bounded thing and did not admit that one could even think of what is not [void], while Leucippus posited the atoms, an infinite number of elements in continual motion, and held that they have an infinite number of shapes, since there is no more reason for them to be one shape than another, and that come to be and change are unceasing among the things that there are. Further, that which exists no more than that which is not, and both are alike causes of the things that come to be. For positing the nature of the atoms as solids and a plenum he said that it is 'what is' and that **it travels about in a void**, which he called 'what is not' and said that it is no less than what is."
>
> — Simplicius (c.530), Commentary on Aristotle's *Physics* (28.4-27)

To restate, as summarized cogently by James Partington, in his *A Short History of Chemistry* (1957), via citation to Aristotle:[6]

> **Eleatic school** (Xenocrates, Parmenides, Zeno): Without a vacuum, there is no motion; *there is no vacuum* [because being cannot go into non-being], hence there is no motion.
>
> **Atomic school** (Leucippus, Democritus, Epicurus): Without a vacuum, there is no motion; *there is motion* [it is observable around us], hence there is a vacuum.

This new 'atoms and void' school carried forward, as a matter of fact, into the mind of Epicurus, who penned an entire book, now lost, entitled *Of Atoms and Void* (c.290BC), wherein he, supposedly, expounded on the theory of the existence of atoms moving in a void. The gist of this new atomic theory void-accepting school of thought, is summarized as follows:

> "All of the atomic theorists, i.e. Leucippus, Democritus, Epicurus, and many others, cite the involvement of the 'void' as the cause of the differentiation of the corpuscles, since what is truly continuous in their view indivisible. Democritus, in particular, says that **'void' is *not-being*** and a privation."
>
> — Themistius (c.320AD), Commentary on Aristotle's *Physics* (123.18-20; 129.8-9)

In. c.390BC, Plato, conversely, who hated the ideas of Democritus, and his school, e.g. he famously professed a desire to burn all of Democritus' books, came to find, naturally enough, the idea of a vacuum

inconceivable. Plato, in turn, passed his views along to Aristotle, who in c.350BC declared the now-famous dictum *horror vacui* or 'nature abhors a vacuum', on the logic that in a 'complete vacuum', infinite speed would be possible, because motion would encounter no resistance; hence, per reasoning that infinite speed was impossible, so too is a vacuum.

While the subject of 'Parmenides vs Heraclitus' is a seemingly prolonged topic, in and of itself, the point to note here, is that Parmenides' denial of the void is an historical **anchor point** in the history of thermodynamics. Specifically, as we will shortly discuss, Parmenides' denial of the void, as it was digested by the mind of Aristotle, later spurred on the inquisitive mind of Otto Guericke (1647), who decided he would settle the matter of the vacuum debate, by making a vacuum, experimentally, which thus resulted in the invention of the *piston and cylinder*. This invention, led to the later invention of the *steam engine*, by Denis Papin (1690), which was transformed into the theoretical *Carnot engine*, by Sadi Carnot (1824), which gave birth to the science of *thermodynamics* by Clausius (1865), which then became the science of *chemical thermodynamics*, via of Gibbs (1876), Lewis (1923), and Guggenheim (1933), and from thence *human chemical thermodynamics*, as has now very-slowly been developing in the last century.

Synopsis: (add)

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2. Algra, Keimpe. (1995). *Concepts of Space in Greek Thought* (pg. 43). Brill.
3. (a) Anon. (2012). "Introduction to Parmenides" (O), Academy of Ideas, YouTube, Dec 17.
(b) http://www.eoht.info/page/Nothingness
4. http://www.eoht.info/page/Greek+philosophy
5. Luckhert, Karl. (1991). *Egyptian Light and Hebrew Fire: Theological and Philosophical Roots of Christendom in Evolutionary Perspective* (pg. 211). SUNY Press.
6. Partington, James. (1957). *A Short History of Chemistry* (pg. 164). Dover.
7. http://www.eoht.info/page/god+void
8.

6. Aristotle (350BC)

> "Did vast, intermediate, and endless space fill me with curiosity and infuse me with a desire to investigate it. For indeed, **what is it?** Inasmuch as it contains all things, it serves as a **place** for 'being' and 'existing'."
>
> — Otto Guericke (1672), *New Magdeburg Experiments on the Vacuum of Space* (pg. 84)

Chapter point: to introduce Aristotle's discussion of 'place', which later would significantly stimulate the mind of Otto Guericke (1647), the inventor of the vacuum pump, the piston and cylinder, and the popularization of the premise the *power of the vacuum*, and its ability to do work. We will also summarize Aristotle's model of 'teleology', or the destiny of things. [length: 4-pgs]

In 350BC, Aristotle, in book one of his *Physics* treatise, stated that when the objects of an inquiry, in any department, have principles, causes, or elements, it is through acquaintance with these that knowledge and understanding is obtained, per the reasoning that we do not think that we 'know a thing', until we are acquainted with its primary causes or first principles, and have carried our analysis as far as its elements.

These principles in question, in Aristotle's time, were divided between two schools of thought, namely: those of the philosophical school of Parmenides and Melissus, who adhered to the 'motionless model' of all things, according to which all that exists is one and motionless, and those of the physicists school of Democritus and Leucippus, the atomists, Heraclitus, the flux and fire philosopher, and Anaximander, Anaxagoras, and Empedocles, the mixture and segregation of elements thinkers, all of whom adhered to a 'motion model' of things. Aristotle, in his *Physics*, compares and contrasts the logic of these two schools of thought.

In book four of his *Physics*, Aristotle jumps from a discussion of motion, to a discussion of 'place', in respect to motion, per his view that motion in its most general and proper sense is change of place; he explains this as follows:

> "The physicist must have a knowledge of '**place**', too, as well as of the infinite—namely, whether there is such a thing or not, and the manner of its existence and what it is—both because all suppose that things which exist are somewhere (the non-existent is nowhere: where is the goat-stag or the sphinx?), and because motion in its most general form and proper sense is *change of place*, which we call locomotion."
>
> — Aristotle (c.322BC), *Physics* (§1.4, pgs. 354-55)

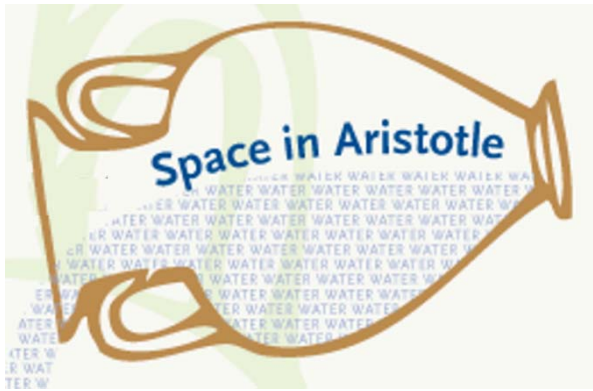
The term *loco*-motion, from the Latin *locus* + English *motion*, to clarify, means a change of location, or an act or power of moving from one place to another place.[4] In Aristotle's theory, his model of place and the power of moving from one place to another, held at the element scale and the human scale.

Aristotle, then goes into his conceptual model of place, by using the analogy or model of a vessel that is able to hold water or air:

> "The existence of '**place**' is held to be obvious from the fact of mutual re-*place*-ment. Where water now is, there in turn, when the water has gone out as from a vessel, air is present; and at another time, another body occupies this same place. The place is thought to be different from all bodies which come to be in it and replace one another. What now contains air formerly contained water, so that clearly the **place or space** into which and out of which they passed was something different from both. Furthermore, the locomotions of the elementary natural bodies, namely: fire, earth and the like, show not only that 'place' is something, but also that it **exerts a certain influence**."
>
> — Aristotle (c.322BC), *Physics* (§1.4, pg. 355)

Here, according to Aristotle, place or space exerts a certain influence. Moreover, and more importantly, i.e. important to the development of the science of thermodynamics, is that we are being painted a mental picture of some sort of vessel, cup, vase, or possibly a barrel, or a shape of some sort, defined by a boundary, into or out of which substances, such as liquids or gases, can pass. Aristotle, in other words, is beginning to adumbrate what we now refer to as the thermodynamic 'system', albeit in very basic and

rudimentary terms. The adjacent image, form the 2011 Topi.org conference on 'Changing Places: the Physics and Metaphysics of Space in Aristotle', gives a general idea of visual model of Aristotle's concept of a 'vessel', with a defined boundary, that acts as the container for the 'place' or space of something, such as wine, water, or air.



The following, to clarify further, are a few key quotes from Aristotle's chapter on place:

> "The 'plenum' [space with atoms] and 'void' [space without atoms], according to Democritus, exist, the one as '**being**', the other as '**not being**'."
>
> — Aristotle (350BC), *Physics* (§1.4)

> "The theory that the 'void' exist, involves the existence of place, for one would define void as a place bereft of body."
>
> — Aristotle (350BC), *Physics* (§1.4, pg. 355)

Next, following a citation of Hesiod who says: 'first of all things, came chaos to being, then broad breasted earth', which is but a secular rescript of the Egyptian creation model, Aristotle begins to speak about the supposed 'power of place', a forerunner to the later concept of the power of the vacuum:

> "The **power of place** must be a marvelous thing, and be prior to all other things. For without which nothing else can exist, while it can exist without the other, must need be firs; for **place does not pass out of existence** when the things in it are annihilated."
>
> — Aristotle (c.322BC), *Physics* (§1.4, pg. 355)

In the next statement, we move into a difficult conceptual topic of discussion:

> "Also, we may ask: of what in 'things' is space the cause? None of the four modes of causation can be ascribed to it. It is neither cause in the sense of the matter of 'existences', for nothing is composed of it, nor as the form and definition of things, nor as end, nor does it move existents."
>
> — Aristotle (c.322BC), *Physics* (§1.4, pg. 356)

In the modern view of things, when action such as combustion occurs, the chemical reaction actuates a bond change, which in turn yields a geometrical change in space or 'place' as Aristotle would define things, per reason that the valence shell electrons of the atoms involved in the reaction migrate into a new more stable arrangement. This new electron arrangement, in turn, moves the nucleus of each respective atom, according to which the products have a different space or place than as compared to the reactants. This will be evidenced in the Da Vinci chapter on the gunpowder combustion engine, wherein the explosion of gunpowder actuates a vacuum, inside of the place, in da Vinci's case a cannon barrel, and resulting place or vacuum does move existents, namely the piston of his cannon barrel, which lifts a weight in the air.

In the chapter on Lawrence Henderson, we will discuss causation in more detail, per reason that Henderson, in his 1940s Harvard Sociology 23 course, devoted considerable time on discussion of the new post-thermodynamics era reformulation as causation reinterpreted as change of state, wherein causation models, to some extent, become obsolete, or at least upgraded, so to say.

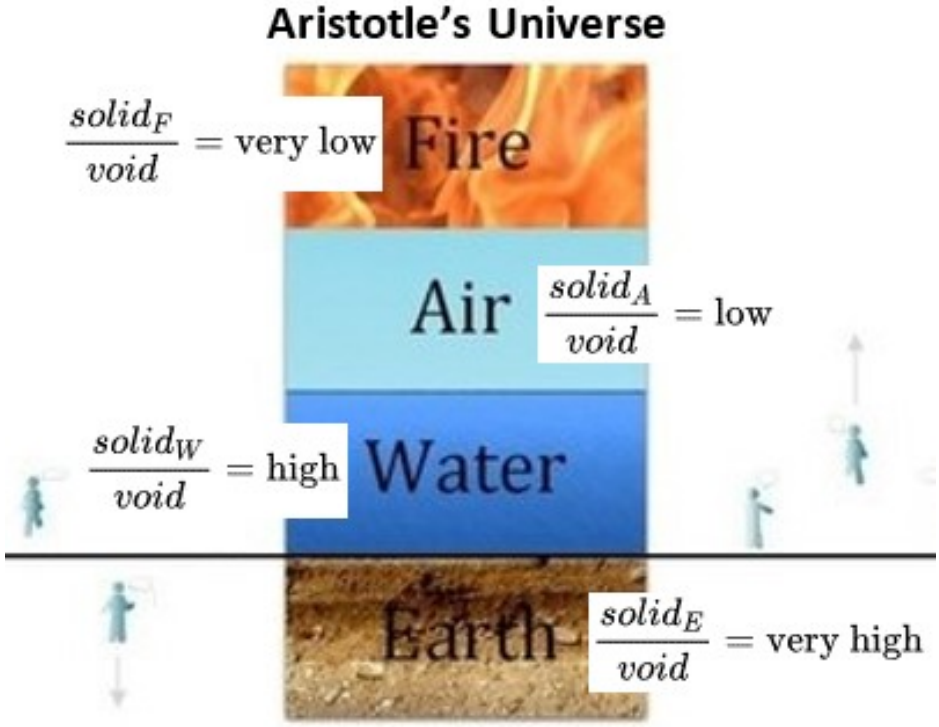
6.1 | Teleological Physics

The second main aspect of the work of Aristotle, we need to take note of, in respect to its ongoing residual implications seen in modern debates on the topic of chemical thermodynamics applied socially, is his concept of *teleology*, from the Greek *telos* 'end' + *-logia* 'divine origin', a doctrine holding that matter — specifically matter of the four elements: earth, air, water, fire — or matter in any its modern formulations, e.g. sentient matter — has a goal, conceived as its 'purpose', which is to go to its natural place, i.e. its 'end' or 'final cause', its satiated location in the cosmos, in short.

As to where this concept derives, the following statement points to a belief, by Aristotle, in the possible existence of a *partial* void, or at least a ratio of solid-to-void existing in nature:

> "For any two portions of fire, small or great, will exhibit the same **ratio of solid to void**; but the upward movement of the greater is quicker than that of the less, just as the downward movement of a mass of gold or lead, or any other body endowed with weight, is quicker in proportion to its size."

On this basis, in Aristotle's scheme, the universe consisted of four elements: water, earth, fire, and air, which were said to move according to what he called a 'teleological principle', according to which each element or thing had a certain density, or solid to void ration, the lighter ones, tending to rise, the heavier one's tending to sink, such as depicted below:



Here, according to this model, all things in the universe, in Aristotle's view, were said to *seek* their natural place in the universe. The following summaries the gist of Aristotle's teleological physics, namely how *place* exists, how there are *elements*, and also how an *inclination* exists working to move things to their natural place in the cosmos:[2]

> "Place, according to Aristotle, resembles form and is the first limit of the containing body. Hence, the cosmos is intrinsically directional: 'up', 'down', 'left', 'right', 'front', and 'back' are not just relative to us but are given in the cosmos itself. Within the cosmos all things, whether made or natural, animate or inanimate, are made up of the elements, and there is nothing material outside the cosmos. Each element possesses a specific nature, its **'inclination': the active orientation of each element toward its proper place**, e.g., up or down. Consequently, place and inclination work together place constitutes the formal limit and directionality of the world, the 'where things are', while each element is limited and possesses inclination toward its proper place. As a result of this partnership, natural motion in things, in the absence of hindrance, is completely regular it exhibits the order of nature and the account of nature as itself orderly."
>
> — Helen Lang (1998), *The Order of Nature in Aristotle's Physics: Place and the Elements* (pg. 10)

Plato's conception of soul mates, is the one of the more famous examples of this scheme. In Plato's model, humans originally were thought to be formed in pairs, at first mixed together into one formed mass, like a ball of clay on a potter's wheel. The divine potter, e.g. the god Zeus, as Plato described things, to the formed mass, replete with some type of soul substance, and split it in half, and used one chunk of this divine clay to form the man, the other chunk to form the woman. These male-female pairs, were then set adrift, after which, many years later, each human spent their days roaming the earth in search of their long lost soul mate, owing to this natural purported natural inclination of things to find their proper place in the universe. Plato, in turn, taught some variant of this to Aristotle, his student, some aspects of which we glean in Aristotle's inclination theory based teleology model element motion.[3]

Aristotle, in turn, taught his cosmology to Alexander the Great, his pupil. In the centuries to follow, through the influence of Alexander, in forming the Greco-Roman empire, Aristotle's general cosmological model soon became the standard scientific model of things, for nearly the next two millennia.

Synopsis: (add)

References

1. http://www.eoht.info/page/Place
2. Lang, Helen. (1998). *The Order of Nature in Aristotle's Physics: Place and the Elements* (pg. 10). Cambridge, 2007.
3. http://www.eoht.info/page/Soul+mate
4. Merriam-Webster Collegiate Dictionary (2000).
5.

Engines

In the following **set of chapters**, we will be covering the development of the steam engine, from Hero, to Watt, all of which were subsumed in 1824 by Sadi Carnot, in his abstract Carnot engine.

(add)

8. Hero's *Pneumatica* (50AD)

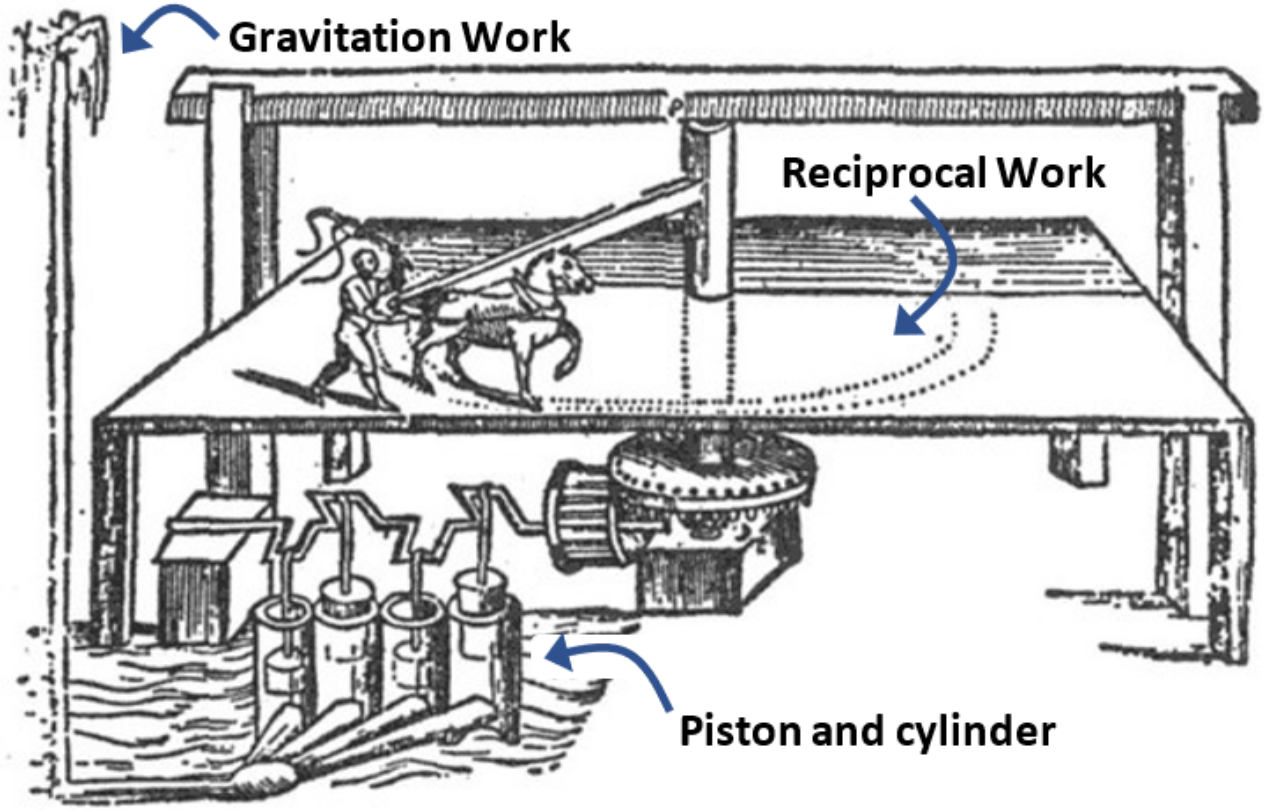
"It is said that Ctesibius invented the **piston and cylinder** before 200BC."
— Richard Kirby (1956), *History of Engineering* (pg. 154)

Chapter point: Give the general overview of the Greek to Italy to Europe transmission of ideas about pneumatics and fire-based steam produced motion, thanks to Hero's *Pneumatic* [length: 8-pgs]

In 230BC, Ctesibius, pronounced 'Ta-sib-e-us', a Greek engineer and mathematician, was noted for a number of inventions, such as the 'aeolipile' (heat engine), piston and cylinder (system), pipe organ (hydraulics), counterweight adjustable mirrors, a water clock (clepsydra), force pumps (water lifting device), the principle of the siphon; he published *On Pneumatics*, now lost on the elasticity of the air.

In 50AD, Hero, a Greek physicist, engineer, and mathematician, in his *Pneumatica*, compiled all the wisdom previous to him in respect to pneumatical machinery, particular the work of Ctesibius and the physics of Strato, and described 78 pneumatical devices, such as automatons, singing birds, and solar-powered water fountains, among others, that operate via either air pressure differences and or heating effects.

The following, below right, shows a four-cylinder one-horsepower pump, which, supposedly, is found in one of Hero's 1589 *Pneumatica* reprints, which illustrates the transformation of **rotary motion**, via gears, to **reciprocating motion**, in the form of the piston rod going up and down, which works to pump water upwards, thus doing gravitational work, or weight lifted though a height:



The following shows, at left, Hero's design for opening temple doors with fire; his aeolipile, center, an early steam turbine; and, at right his syringe, used for either ejecting things, or for sucking up things:[1]

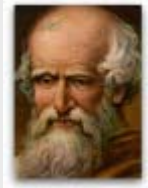
In his description of the syringe, Hero, of note, differing from the standard Aristotle model of things, freely advocates the existence of the vacuum in his description of the syringe's operation:

> "The instrument called a 'pyulcus' [syringe] acts on the same principle. A hollow tube, of some length, is made, A B; into this another tube, C D, is nicely fitted, to the extremity C of which is fastened a small plate or piston, and at D is a handle, E, F. Cover the orifice A of the tube A B with a plate in which an extremely fine tube, G H, is fixed, its bore communicating with A B through the plate. When we desire to draw forth any pus, we must apply the extreme orifice of the small tube, H, to the part in which the matter is, and draw the tube C D outwards by means of the handle. As **a 'vacuum' is thus produced** in A B something else must enter to fill it, and as there is no other passage but through the mouth of the small tube, we shall of necessity draw up through this any fluid that may be near. Again, when we wish to inject any liquid, we place it in the tube A B, and, taking hold of E F, depress the tube C D, and force down the liquid until we think the injection is effected."
>
> — Hero (50AD), *Pneumatica* (device #57)

In the 13th century, and nearly every century to follow, Hero's *Pneumatica* was translated and reprinted in nearly all countries, but particularly in Italia at first, where it began to have gradual effect, in the slow, trial and error, development of many types of air pressure and steam devices and engines, which is difficult to pin down in any exact way.

8.1 | Engine Pioneers

The following is online engine development table, which gives short historical overview of the chronological development of the heat engine, Archimedes to Carnot, be it a vacuum engine, heat engine, steam engine, or combustion engine:[2]

	Person	Date	Engine	Description
1.	 Archimedes (287-212BC)	c.235BC	Architronito (steam cannon)	Invented, according to da Vinci (c.1500), a so-called architronito, or steam-powered cannon that throws 70lb iron balls, via the action of "great noise and fury", at the enemy, by the action of heat derived from burning coals; diagrams of which are found in da Vinci's notebooks.

2.	Ctesibius (c.285-222BC)	c.230BC	Aeolipile	
3.	Hero (c.10-70AD)	c.50AD	Aeolipile	
4.	Leonardo da Vinci (1452-1519)	1508	Da Vinci engine [s] Type: Gunpowder engine Steam cannon Steam turbine	Da Vinci, according to the arguments of Ladislao Reti (1969), was the first to: state that condensed steam makes a vacuum, before Gerolamo Cardano (1550) is blurrily-cited to have done so; first to make a gunpowder engine, before Christiaan Huygens (1673), Denis Papin (1674), and Jean Hautefeuille (1678); was the "unknown author" cited by Giovanni Branca (1629), in respect to his Hero-like steam turbine; and that he was the true inventor of the steam-powered cannon (Architronito), not Archimedes, per argument that Archimedes only invented an ordinary gunpowder cannon.
5.	Gerolamo Cardano (1501-1576)	1550		
5.	Lazarus Ercker (c.1530-c.1594)	1574		
6.	Giovanni Porta (1535-1615)	c.1601	Porta engine Type: Improved Hero fountain	In his *Spiritali*, following or amid a French translation of Hero's steam machine work, reproduced Hero's aeolipile and his solar boiler device, after which, he added an illustrated modified variant of his own, similar to a combination of the above two devices; as shown below, wherein, a fire is put under flask a, filled with water, which makes steam, that enters closed container b, filled with cold water, which forces the water to shoot out of tube c, into the external air.

7.	Cornelis Drebbel (1572-1634)	1609		
8.	Salomon de Caus (1576-1626)	1615	Caus engine	
9.	Giovanni Branca (1571-1645)	1629	Steam turbine Type: Modified aeolipile	
10.	David Ramsay (c.1590-1653)	1630	Ramsay engine (aka fire engine)	Under the idea influence of de Caus, applied for a patent for a device "To Raise Water from Lowe Pitts by Fire"; supposedly, however, there is no information concerning what he had in mind or what he did with it.
11.	Galileo Galilei (1564-1642)	1632	Galileo engine (vacuum measuring device)	
12.	Otto Guericke (1602-1686)	1647	Guericke engine (aka vacuum pump)	
13.	John Wilkins (1614-1672)	1648		His *Mathematical Magic* (1648) presented a chapter on the history of heat engines of various sorts, e.g. aeolipile, Giovanni Branca's device (1629), and Cardano's smoke jack, and Cornelis Drebbel's sun-powered clavichord (1609).
14.	Robert Hooke (1635-1703) | **#1**	1658	Pneumatical engine (aka machine Boyleana)	An improved re-construction of the Guericke engine, built per order of Robert Boyle.

15.	Samuel Morland (1625-1695) | **#1**	1661		Was granted a 'monopoly', according to a warrant of Charles II, for an engine for raising water out of mines by means of 'air and powder conjointly'."
16.	Edward Somerset (1603-1667)	1663	Worcester engine (Thurston, 1878) (aka Somerset engine)	
17.	Ferdinand Verbiest (1623-1688)	c.1670	Verbiest auto-mobile	
18.	Christiaan Huygens (1629-1695)	1673	Huygens engine Type: Gunpowder engine; Piston and cylinder	
19.	Robert Hooke (1635-1703) | **#2**	1675	Hooke engine Type: Theoretical	
20.	Denis Papin (1647-1712) | **#1**	1674		A few years subsequent to Boyle's discoveries [1662], Papin was installed in the laboratory at the Parts Academy of Sciences, and under the directions of Christiaan Huygens, was employed in experiments with the pneumatic engine, after the model of Boyle and Hooke's, and the examination of the force of gunpowder, and also of the force of water rarefied by fire. An account of these experiments was published in 1674, and in the following year Papin left Paris, and proceeded to London. [2]

21.	Jean Hautefeuille (1647-1724)	1678	Hautefeuille engine Type: Gunpowder engine	
22.	Denis Papin (1647-1712) | **#2**	1679	Papin digester	invented what he called a "digester or engine for softning bones", aka "bone digester", or Papin's digester as it later came to be called
23.	Samuel Morland (1625-1695) | **#2**	1683	Morland engine	Submitted a project to Louis XIV for raising water by means of steam, accompanying it with ingenious calculations and tables.
	Denis Papin (1647-1712) | **#3**	1688	Papin engine (gunpowder)	
24.	Denis Papin (1647-1712) | **#3**	1690	Papin engine (steam) Type: Theoretical; Piston and cylinder	
25.	Thomas Savery (c.1650-1715)	1698	Savery engine (aka Miner's friend)	
26.	Thomas Newcomen (1664-1729)	1705	Newcomen engine (improved Savery engine)	
26.	Henry Beighton (1687-1743)	1717		In two entries of the Royal Society (1717), he made an improved Newcomen engine (O); sometime thereafter he began to associate with John Desaguliers. (O)

27.	John Desaguliers (1683-1744)	1718		
28.	James Watt (1736-1819)	1765	Watt engine (improved Newcomen engine)	Made a number of inventions and design improvements to the functionality of the steam engine, including: separate condenser (1765), the fly-ball governor (1788), and the definition of "pony power" (or horse power).
29.	Joshua Rigley (c.1710-1785)	c.1768		
30.	John Smeaton (1724-1792)	1769	Smeaton engine (improved Newcomen engine)	
31.	Nicolas Cugnot (1725-1804)	1769	Cugnot auto-mobile	
32.	James Pickard (c.1735-1800)	1780	Pickard engine	
33.	Jonathan Hornblower (1753-1815)	1781	Hornblower engine (compound engine)	
34.	Arthur Woolf (1766-1837)	1803		Designed an improved boiler for producing high pressure steam (1803) and invented a compound steam engine (1804) generally using the expired patent of Hornblower.
35.	Richard Trevithick (1771-1833)	1804	Trevithick locomotive	
36.	George Stephenson (1781-1848)	1814		
37.	Sadi Carnot (1796-1832)	1824	Carnot engine Type: Abstract	

In this table, firstly we not the over-prevalence of the name Denis Papin, a French super-engine pioneer, so

to say, who after working with Huygens, on gunpowder engines, the Boyle, the pioneer of vacuum experimental research, where he built his pressure cooker, then Hooke, who had penned a cyphered heat engine principle, then on to his own work, eventually resulting in the Papin engine (1690), which eventually became the Carnot engine (1824), upon which thermodynamics was derived.

Secondly, although we see the piston and cylinder being employed by the Greeks, it was Otto Guericke who can be credited predominately with the piston and cylinder used to day in cars, and it started from his use of a syringe-like water squirt gun, typically employed in Germany in the 1640s to put out fires, from where he made the first piston and cylinder, and showed that by the power of the vacuum, it could lift several thousand pounds off the ground.

Thirdly, and lastly, the above table compresses a large amount of historical background into a shorthand version of things. The reader is encouraged to the online version of this table, and at least click through the names of each hyperlinked engine development pioneer, and read through each of their articles and related engine development technologies, in overview, before proceeding, to get a general big picture view of things, in respect to how engine technology developed and evolved over the centuries.[2] Herein, in the following chapters, we will focus in on the main players in this table, in respect to there direct involvement in the formation of thermodynamics, such as Guericke, Boyle, Huygens, Papin, Savery, Newcomen, and Watt.

In the chapter to follow, we will see that, of interest to thermodynamics Hero was read by Leonardo da Vinci, and through his mind, we see the first combustion engine, a general acceptance of the vacuum model of things, which Hero adhered to, in opposition to the Aristotle denial of the void or vacuum model.

Synopsis: (add)

References

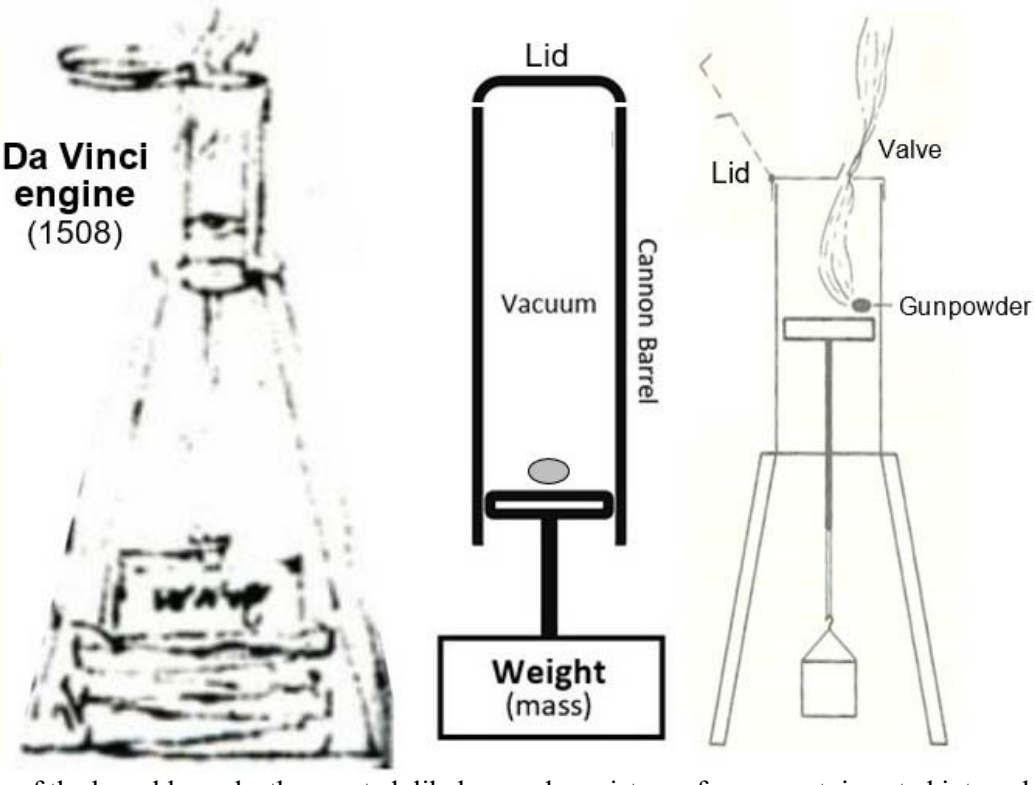
1. Hero. (50AD). *Pneumatics* (translator: Bennet Woodcroft). Taylor, 1851.
2. http://www.eoht.info/page/engine+pioneers
3.

9. Da Vinci Gunpowder Engine (1508)

> "European scholars in 1500, still held to the Greek view which did not distinguish steam from air. The **vacuum was not understood**; it was still something 'abhorred by nature'. Girolamo Cardan [c.1560] suggested that a vacuum might be produced by the condensation of steam. Giovanni Porta, an Italian philosopher, came close to distinguishing steam from air, but did not make the conception explicit. It was Solomon de Cans (1576-1630), a French landscape gardener and engineer, who 'took this decisive step', according to Usher (1929): he declared that steam is evaporated water; that upon cooling the vapor 'returns to its original condition'."
>
> — Leslie White (1975), *Modern Capitalist Culture*

Chapter point: Introduce the da Vinci gunpowder engine (1508), define the thermodynamic 'system', and on this model explain the social thermodynamic 'system' [length: 6-pgs]

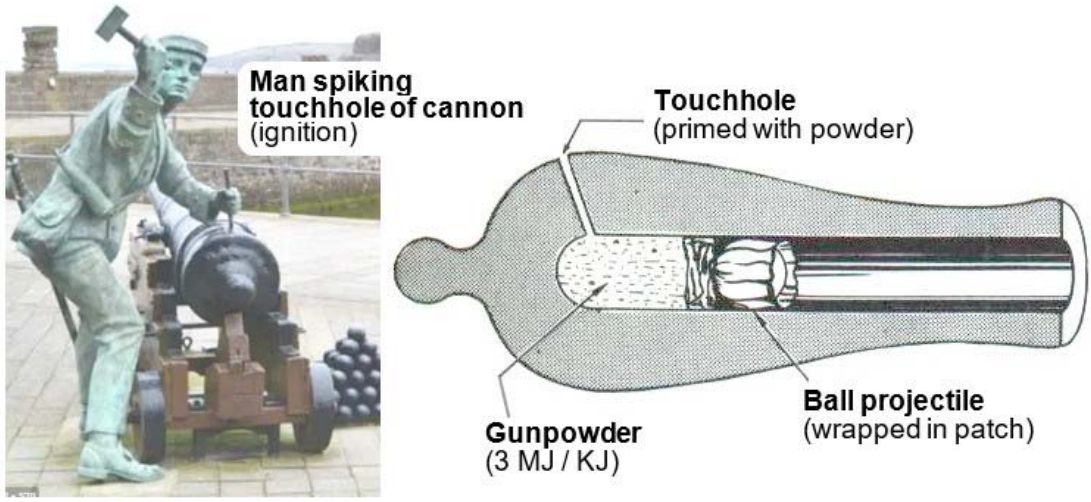
In 1508, Leonardo da Vinci, in his folio 16v of manuscript F, sketched a gunpowder combustion engine, as shown below (left), which consists of a two-foot by eight-foot cannon barrel, supported in a frame, so that the barrel remains vertical, constructed such that at the top of barrel sealable lid is affixed, which has pressure release valve built into it:



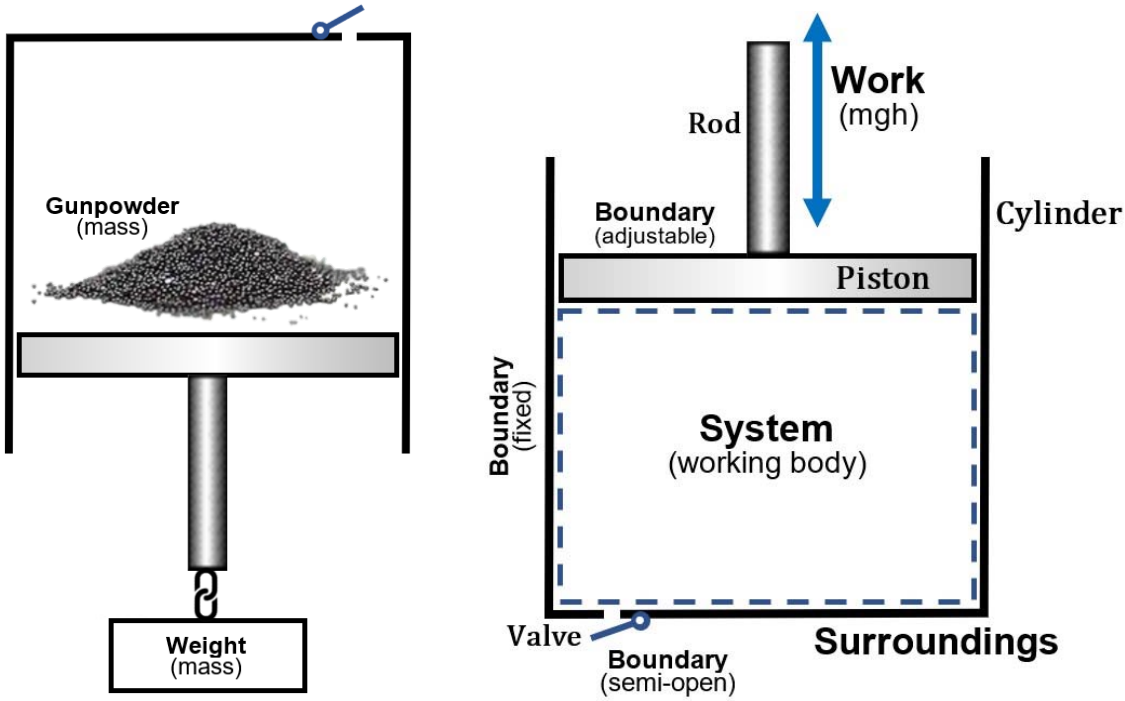
The bottom of the barrel has a leather coated, likely wooden, piston, of some sort, inserted into, which is attached to a weight, which is to be lifted. To operate the device, an amount of gunpowder is placed inside the cannon. The lid closed and sealed. The gunpowder is ignited by 'striking the touchhole', which thus imparts impacting kinetic energy to the powder, setting it into combustion. Da Vinci described his gunpowder engine as follows:

> "A mechanism to lift heavy weights. **To lift a heavy weight with fire**, like a cupping glass. And the vessel should be one braccio [about 2 feet] wide and ten long, and should be strong. It should be lit from below like a bombard [cannon] and the **touchhole** rapidly and immediately closed on top. The **bottom** [thing], that has a very strong leather [seal], like a bellow, **will rise** and this is the way to **lift any heavy weight**."
>
> — Leonardo da Vinci (1508), "note on device to lift heavy weight with fire", Folio 16v of MS F

His engine consists of a cannon barrel fitted with a closable lid, and an exhaust fumes release valve, on the top, which operates such that when gunpowder is placed on the piston and ignited, an explosion occurs, the reactant vapors leave through the release valve, and a vacuum or partial vacuum is made to form inside the piston and cylinder, thereby acting to make the piston rise in the cylinder, lifting weight, by the force of the weight of the atmospheric pressure, pushing upward on the bottom of the piston.[1] The following, to clarify terminology, shows the basic components of a standard cannon:



Below left, we see an image reconstruction of the basic components of da Vinci's gunpowder engine, or internal combustion engine as we now classify things, widened and shortened for the sake of illustration clarification, where the cannon barrel is the 'cylinder' and his '**bottom** [thing], that has a very strong leather [seal]' is the piston:



Above right, we have the same engine, only inverted, and shown labeled with modern thermodynamics terminology.

The mass of gunpowder, in da Vinci's engine, together with the mass of air, inside the volumetric region contained within the piston and cylinder, as indicated by the dotted region above, constitutes the 'system' or 'working body' (Clausius, 1865), meaning the *body* that either does work on the surroundings, e.g. if it pushes its volume outward, or the body that has work done on it by the surroundings, e.g. if the surroundings compress the volume of the system, the 'surroundings' in this case being the weight or mass of

atmosphere, surrounding the system. The surroundings here, in respect to the system shown, refers to mass of air surrounding the piston and cylinder that extends 62-miles in height above the surface of the earth, pressing down on the piston.

Normally, the air in the system *balances* the pressure of the weight of the atmosphere, and the piston doesn't move. When, however, gunpowder explodes in the system, the pressure of the explosion 'forces' all the gases products *out* of the system, through the release valve. When the gases have escaped, the release valve automatically closes, leaving a partial vacuum inside the system. With nothing left inside the system, the weight of the atmosphere, i.e. the surroundings, push down on the piston with strong force or with enough power to lift mass attached to the rod, as da Vinci has things arranged.

9.1 | Gunpowder Explosion Chemical Reaction

Chemically speaking, the following shows the simplified chemical reaction for the combustion of gunpowder:

$$2KNO_3 + S + 3C \rightarrow K_2S + N_2 + 3CO_2$$

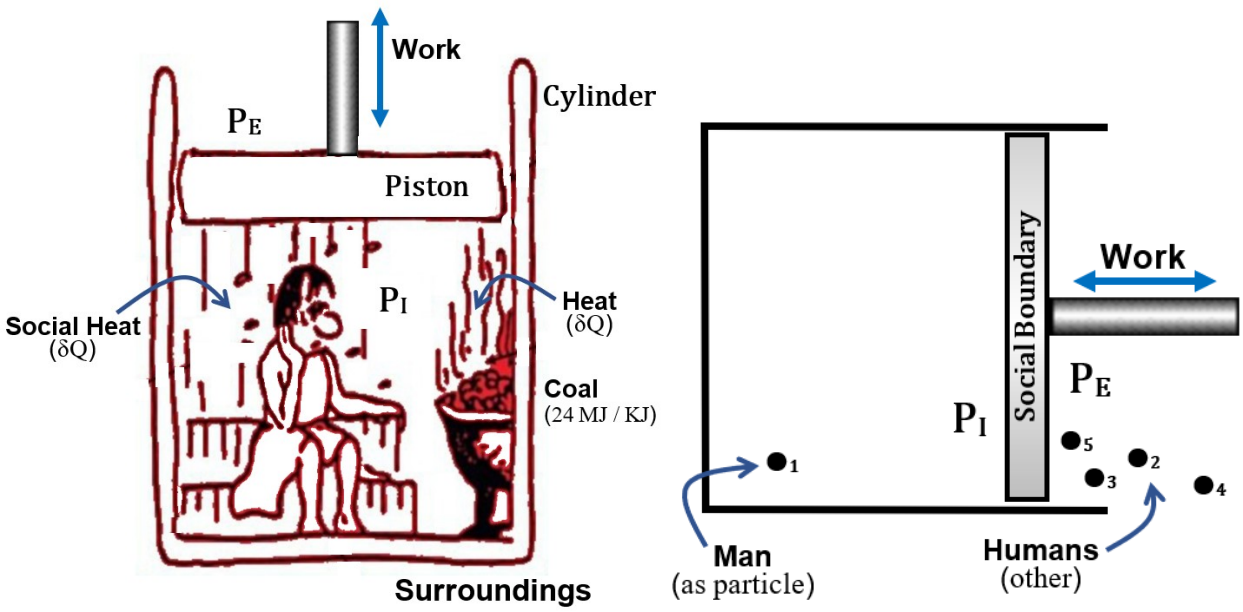
wherein, a 'solid' reactant, a mixture of potassium nitrate (KNO_3) (75%), charcoal (C) (15%), typically in the form of partially pyrolyzed cellulose, in which the wood is not completely decomposed, and sulfur (S) (10%), are ignited, causing an explosion, and yielding the products of potassium sulfide (K_2S), the gases nitrogen (N_2) and carbon dioxide (CO_2), along with a small amount of water (not shown):

Solid (100%) → solids (56%) + **gases** (43%) + liquid (1%)

This reaction releases 3 megajoules of energy per kilogram of gunpowder, and contains its own oxidant, which can be compared to dynamite (4.7 megajoules per kilogram) or gasoline (10.4 megajoules per kilogram).

9.2 | Social Piston and Cylinder Engine

To help us conceptually understand how the thermodynamic 'system' model scales up to the social reaction level, the following, below left, we see Ingo Muller's 1994 'man in piston' diagram, with add annotations:



The man, as we note, is shown to be emotionally disturbed, in some way, wrapped in some troubling or vexing problem, the dots around him meant to represent social heat, the vertical lines, meant to represent liquid condensate. In respect to 'heat', say when comparing the heat given off in the gunpowder explosion, in the da Vinci engine, as compared the heat released from the burning wood or coal in the so-called 'Muller engine', above, as compared to the say the 'heat' of frustration evidenced by the expression of the man in

piston. One example is social friction heat. The following quote by Werner Stark, in summary of the Henry Carey's 1858 *Fundamental Forms of Social Thought*, seems to well characterize a scenario we might see occurring between particles 2 through 4, above right:

> "In the physical universe, heat is engendered by friction. Consequently, the case must be the same in the social world. The 'particles' must rub together here, as they do there. The **rubbing of the human molecules**, which produces warmth, light and forward movement, is the interchange of goods, services, and ideas."
>
> — Werner Stark (1962), *Fundamental Forms of Social Thought* (pg. #)

Here, in the language of Carey, people can either be defined as particles or human molecules, depending on the discussion or point of view at hand. Now, for larger 'explosive' amounts of heat, beyond that of mere social friction, to be released or absorbed (in some cases), bonds have to form or break, which by definition means that a chemical reaction has occurred. In the above human particle scenario, human particle one $\bullet_1$ might escape out of his social system and react with particle two $\bullet_2$, to form a chemical bond; the reaction of which being defined as follows:

$$\bullet_1 + \bullet_2 \longrightarrow \bullet_1 \equiv \bullet_2$$

The attachment of particle one and particle two, in the reactants, signifies a chemical bond, and for this to have occurred, reaction heat would have had to been released or absorbed. To say again, the heat (δQ) of the fire of the wood or coals, which results from hydrocarbon atoms reacting with the oxygen in the air, and social heat (δQ) of society, which results from humans reacting with each other, are of the same nature, but are quantitatively different.

The diagram shown above right, shows the same 'man in piston' system, only re-labeled, using a human particle model, and *turned sideways*, to help exemplify the fact that social pressure, generally speaking, is a side-ways acting phenomenon, which can be contrasted with atmospheric pressure, as seen operating in the da Vinci engine, which has vertical or force normal to the surface of the earth way of operating. Simple to think of examples included gang turf wars or mob bosses muscling in on territories of the competition.

One famously documented example, quantified in terms of exact measurements, is the 1970 to 1974 Gombe Natural Reserve, Nigeria, 'chimpanzee war', which occurred between two rival chimpanzee troops, and was documented and followed, in step-by-stem mechanistic terms, over its entire course, by Jane Goodall.[6] The following synopsis by Helen Fisher states the main points:

> "In the Gombe, wild chimps **patrol territories of up to five to eight square miles**. Regularly, small groups of males **steal along the border** of their range, sniffing the ground for the trace of strangers, and climbing trees to peer across neighboring territories. When an unfamiliar chimp, all except childless females, comes too close, they charge, attack, and occasionally severely injure the intruder. In one instance, an older female was attacked so severely by four males that she died five days later of her wounds. In 1970, a *chimpanzee war* began. A splinter group of seven males and three females with their young split off from their comrades in the north of the reserve and began a group of their own in the south. For a while, individuals **met at the border** to solve their differences by loud calling, hurling branches and mock charges at each other. But in 1974 five males from the original Gombe community began to **roam deep into the southern territory**. Within three years, they attacked and murdered all of the adult males (except two who died of natural causes) and one old female—extinguishing the splinter enclave and **extending their territory** to the south."
>
> — Helen Fisher (1982), *The Sex Contract* (pgs. 62-63)

The discussion of one troop 'extending their territory' here, in chemical thermodynamic terms, refers to one system pushing outward on their social piston, thereby doing work on the surroundings.

Certainly, to clarify, there are situations where vertical social pressures operate, a simple example being the pressures associated with planes in the sky and the stressful working conditions of air traffic controllers. A more quantitative example of vertical social pressures can be seen in skyscraper-lined cities, where penthouses are the most sought-after real estate properties. In Manhattan, e.g., where the average asking price in 2018 was $447/sq.ft., penthouses can cost upwards of $10,000/sq.ft.

To continue, similar in concept to the molecules of the atmosphere having a weight or external pressure, which presses the piston down, when the internal pressure goes to zero, following the gunpowder explosion, so to in at the social reaction scale, will the human molecules of the surrounding 'social atmosphere', so to

say, push inward on any given sub-system, like the man in his home, as shown above, which is characterized by an internal pressure P_I unique to the system, which in the normal state of affairs balances the external pressure. The movement of the social piston will indicate a pressure balance disturbance.

The simplest examples, historically, are when two or more adjacent countries go to war with each other, after which the final territories are different, meaning that someone's piston pushed one someone else's boundary, or the surroundings pushed down on someone's system.

The da Vinci gunpowder explosion can be compared, in some roundabout sense, to a human chemical reaction, wherein a man Mx and Woman Fy, fall in love at first 'sight', and have an 'explosive reaction', the *light* in this case equivalent to the *spark* touching the wick in the gunpowder powder engine explosion, and in their home (system) reproduce three children, who can be considered equivalent to the gaseous products that, nearly adulthood, escape through the release valve of the home; this reaction reads as follows:[4]

$$Mx + Fy \rightarrow MxFy + Bc_1 + Bc_2 + Bc_3$$

where MxFy is the bonded married couple, in the form a new dihumanide molecule, and Bc_1, Bc_2, Bc_3, are the three baby-children prior to becoming adults. In like manner, after the three gaseous products escape through the release valves, e.g. college, job, marriage, etc., the formerly occupied house, now 'empty', equivalent to the 'partial vacuum' made in the cannon, begins to feel the surrounding social pressure, of a husband and wife residing in a large empty, say five-bedroom, home, with no children, and instead of the atmospheric pressure pushing up on the piston, so to contract the volume, the couple sells the home, and moves to a new smaller, retirement home.

Now, how many joules of energy per weight of family 'social powder', so to say, this reaction, on average releases, has not yet been determined. We do note, however, that whereas most families release energy, other families, e.g. those on welfare, absorb energy. In addition, through the study of ATP, which is equivalent to gunpowder, we know that in physiology, energy releasing reactions are 'coupled' to energy absorbing reactions. This will be discussed more when we get to the Lipmann coupling theory (1941) chapter.

9.3 | Nature *allows* a Vacuum?

Technically speaking, if da Vinci performed this experiment, which he likely did in some form, this would have been the first experimental disproof of the ancient Parmenides 'vacuums are impossible' turned Aristotle's 'nature hates vacuums' motto, which held sway in nearly all scientific minds, up into the 1660s, following the vacuum experiments of Galileo (1632), Gasparo Berti (1639), Evangelista Torricelli (1643), Blaise Pascal (1648), and Otto Guericke (1854), which settled the matter, decidedly.

Da Vinci, having read of Hero's *Pneumatica*, held to a Hero-type view on vacuums, believing that they one can make vacuums, but with difficulty, e.g. as in when one attempts to pull on a syringe that has the tip closed with a thumb or something, or when a body moves swiftly through the air, like a horse running, leaving a vacuum in its wake:

> "The motion of the air is seen by the motion of the dust thrown up by the horse's running and this motion is as swift in again filling up the 'vacuum' left in the air which enclosed the horse, as he is rapid in passing away the air."
>
> — Leonardo da Vinci (c.1505), *The Literary Works* (pg. 304)

The following is da Vinci's most-quoted statement concerning vacuums, in respect to the history of steam engines, in that he seems to intuit that condensed steam will make a vacuum:

> "When air [steam] is condensed into rain ***it will*** produce a **vacuum**, if the rest of the air does not prevent this by filling its place, as it does with a violent rush; and this is the wind which rises in the summer time, accompanied by heavy rain."
>
> — Leonardo da Vinci (1505), "Of Rainbows and Rain" (#480); MS E (back cover); Reti (1969) translation[2]

Hence, in da Vinci's mind, when the gunpowder exploded in the cannon, the gases would swiftly escape through release vent, built into the tightly-sealed lid at the top of his cannon, and leave a vacuum in its wake, like the running horse leaving a void behind it, which the air fills with a whirlwind of dust trail behind it, as da Vinci described and drew this type of animal action.

In 1550, Gerolamo Cardano, the inheritor of the da Vinci manuscripts, building on da Vinci, is purported to have said or stated, in his *On the Nature of Things* (pg. 25), that condensed steam makes a vacuum, but the passage is classified by many historians as a famously 'obscure passage'.

It would not be until the next century, with the theoretical Galileo engine (1632), purported to be able to measure the 'strength of the vacuum', the Berti water column vacuum experiment (1639), the Torricelli mercury column vacuum experiment (1644), the Pascal atmospheric pressure experiment (1648), all of which culminating with the 1650s vacuum experiments of Otto Guericke, wherein he evidence the existence and power of the vacuum in a variety of ways, that people could confidently state that vacuums can indeed exist in nature.

The inquisitive reader, at this point, should consult the online 'engine pioneers' table, which lists, chronologically, the main 30+ heat engine pioneers behind the formation of the steam engine or gunpowder engine, up through Sadi Carnot (1834) and the Carnot engine, so to see a working outline of the chapters to follow.[3]

The key concluding point, to note here, is that the year 1508, when da Vinci drew up the above plans for a piston and cylinder internal combustion engine, albeit however crude it was, marks not necessarily the *start of* the science of thermodynamics, but certainly a demarcation point, as an independent discipline of study, concerned with the problem of work done, on or by chemical substances confined to a piston and cylinder volume, via the action of heat or fire, therein relating the principles of the interaction or relation between heat and work mediated by changes in vacuums or voids of space.

Synopsis: (add)

References

1. http://www.eoht.info/page/Da+Vinci+engine
2. Reti, Ladislao. (1969). "Leonardo da Vinci the Technologist: the Problem of Prime Movers", in: *Leonardo's Legacy: and International Symposium* (editor: C.D. O'Malley) §4:67-100; quotes, pgs. 95-98). University of California Press.
3. http://www.eoht.info/page/engine+pioneers
4. (a) http://www.eoht.info/page/human+chemical+reaction+theory
(b) http://www.eoht.info/page/Human+molecular+symbols
5. da Vinci, Leonardo. (1519). *The Literary Works of Leonardo da Vinci: Compiled and Edited from the Original Manuscripts, Volume One* (editor: Jean Paul) (pg. 239-40). Publisher, 1883.
6. http://www.eoht.info/page/chimpanzee+war
7.

10. Beeckman | Atmospheric Pressure (1614)

> "What is the **reason that bodies are moved in any direction**, so that a vacuum may not exist in nature? I answer: it happens that air, after the manner of water, presses, upon things and compresses them according to the depth of the super-incumbent air. But some things remain undisturbed, and are not perpetually moved about, because they are everywhere equally compressed by the air above them, just as our divers are pressed by the water. But things rush towards an empty space with great force, on account of the immense depth of the super-incumbent air, and in this way the weight of the air arises. But air must not be said to be heavy, because we walk in it without any pain, as indeed the fishes move in water, suffering no compression."
>
> — Isaac Beeckman (1614), *Journal Notes*

Chapter point: (add) [length: #-pgs]

In the 1620s, Isaac Beeckman, mentor to Descartes, supreme existive philosopher in the mind of Pierre Gassendi, said to have been influential to Galileo, etc., introduced the so-called first 'molecular' theory of phenomenal matter, according to which all matter is an aggregate of so-called 'physical homogenea' of varying stability. In Beeckman's theory, the homogenea of substances such as metals and medicines are quite stable, while those of light and sound, for instance, are far less so. Beeckman's homogenea are supposed to be composed of four kinds of atoms of one and the same prime matter. Beeckman's theory, while not entirely correct, was a decisive break with Aristotle, and more importantly, in respect to thermodynamics, a break with the long-standing opinion that nature abhors a vacuum.

What is important, in respect to Beeckman, much of whose work seems to be in need of translation and decimation in to English, is that he seems to have been the originator of the premise that air has 'weight', and that it presses down around us like water does on a fish; the following are statements to this effect:

> "It cannot be denied that the lower part of water or air is more strongly compressed than the upper part, since it is compressed by its own weight, as would happen to an immense sponge, its lower part lying on the earth is packed more tightly than the upper part. But this cannot be of great importance in the case of air which by its nature cannot easily be over-compressed and which is not very weighty. Nevertheless, it is necessary to believe that the lower part is as compressed as it could be, by the upper air, and consequently there exists a greater compression at its base."
>
> — Isaac Beeckman (1620), *Journal*; Dec 24; cited by Charles Webster (1965) to argue that this is where Galileo (1632) derived his 'sponge' model of air

> "Air is heavy. It presses us from all sides in a uniform way. Things precipitate into an empty space with great force because of the tremendous height of the air above."
>
> — Isaac Beeckman (c.1625), *Mathematical Physical Mediations* (pg. #)

These views, as we will learn, predate the views of Torricelli (1644) and Guericke (1650s), who both arrived at the same conclusion.

References

1.
2.

11. Galileo (1632)

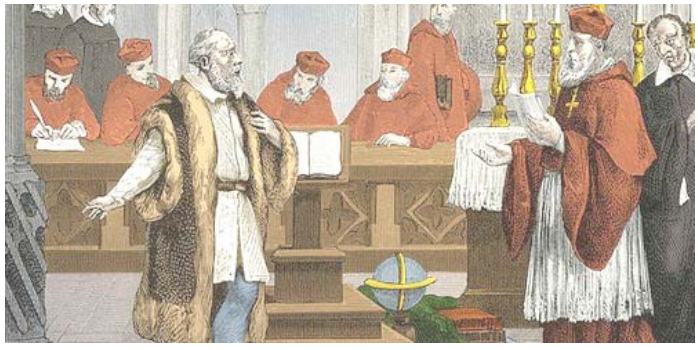
> "In ***dynamics*** is the science of accelerating or retarding forces, and of the varied motions which they must produce. This science is wholly due to the moderns, and Galileo is the one who threw or made the first foundations."
>
> — Joseph Lagrange (1788), *Analytical Mechanics, Volume One* (pg. 221)

Chapter point: (add) [length: 4-pgs]

IN 1543, Nicolaus Copernicus, polish astronomer, published *On the Revolutions of the Celestial Spheres*, wherein the heliocentric theory was established, which marks the start of 'dynamics', the root term in the name thermo-*dynamics*.

In 1602, Galileo Galilei, Italian physicist, began doing 'demonstrations', and developing theorems therefrom, concerning falling bodies and projectiles.

In Jan 1610, news of Hans Lippershey's newly-invented so-called 'Dutch perspective glass', as it was then been called, i.e. telescope, reached the ears of Galileo, who then proceeded to make his own version of what Lippershey had built. The result, was a hand-held tube that allowed one to see things at a resolution 30x that of the eye.



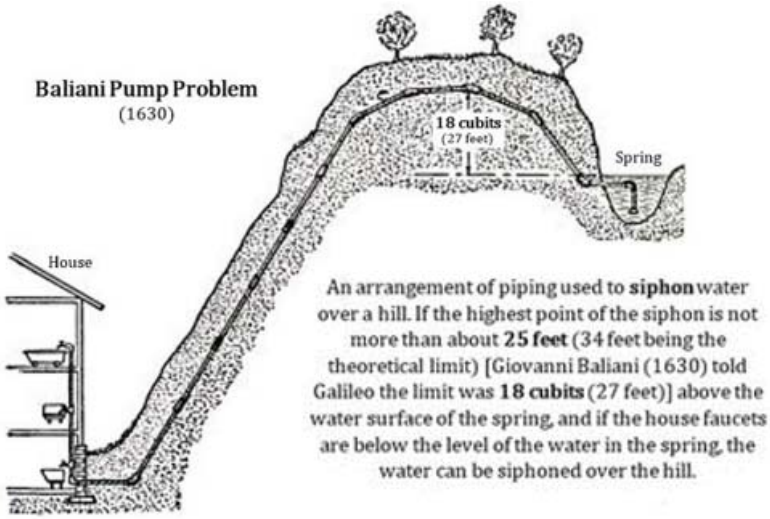
On 13 Mar 1610, Galileo, in his *Message on the Fixed Stars*, presented, to the world, the first published scientific work based on observations made through a telescope, detailing observations of the imperfect and mountainous moon, hundreds of stars that were unable to be seen in either the Milky Way or certain constellations with the naked eye, and moons that appeared to be circling Jupiter.

In 1632, Galileo, in his *Dialogue Concerning the Two Chief World Systems*, compared the then controversial 'Copernican system' with the inconsistencies of the older earth-centric 'Ptolemaic system', and contains all Galileo had to say on physics; this is said to mark the point when *dynamics*, as a science, was founded.

In 1633, Galileo was put on trial for 'suspicion of heresy' for his new telescope measurements based *moving earth theory*, which contradicts the Bible, which holds that the earth is fixed and cannot move, and for his support of the heretical ideas of Copernicus.

11.1 | Pump problem

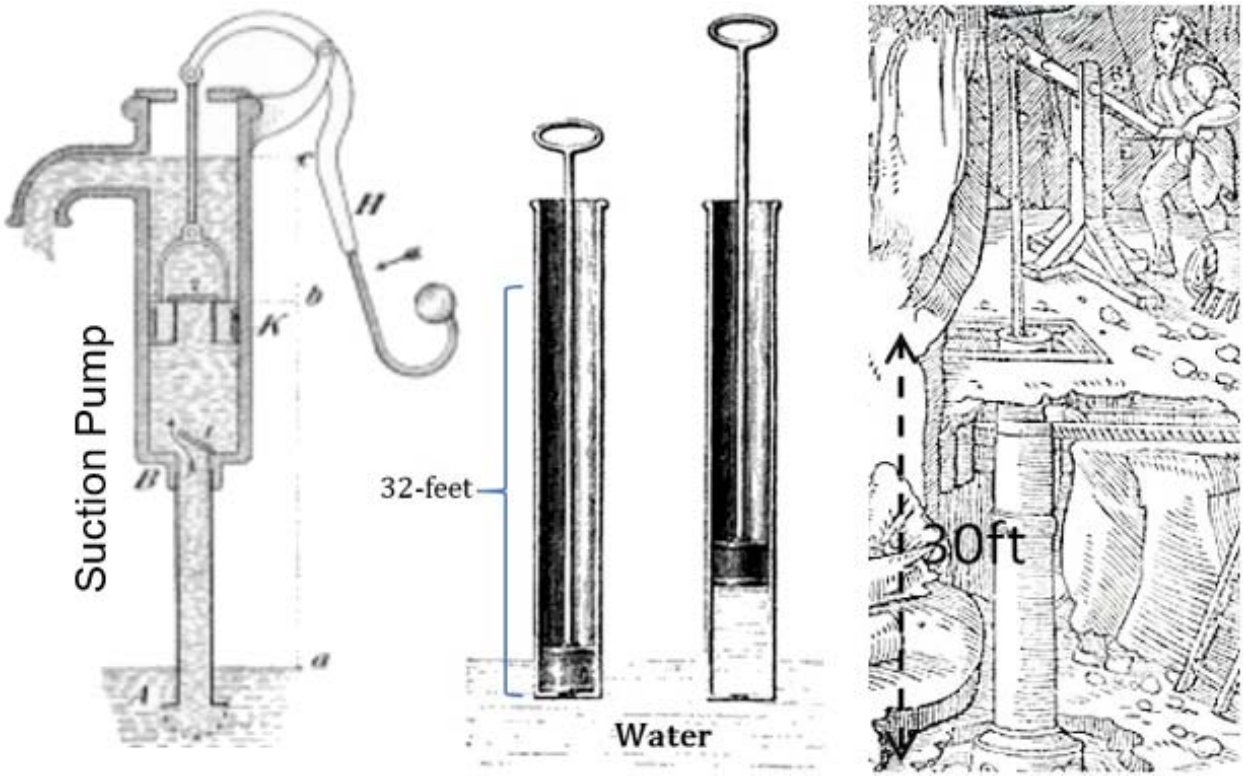
On 27 Jul 1630, Giovanni Baliani, a physicist and experimenter, wrote to Galileo asking him why a siphon, made to carry water over a hill, failed to work if the hill was more than 18 cubits, or about 27 to 32 feet?


Baliani Pump Problem
(1630)
18 cubits
(27 feet)
Spring
House
An arrangement of piping used to siphon water over a hill. If the highest point of the siphon is not more than about 25 feet (34 feet being the theoretical limit) [Giovanni Baliani (1630) told Galileo the limit was 18 cubits (27 feet)] above the water surface of the spring, and if the house faucets are below the level of the water in the spring, the water can be siphoned over the hill.

The image shown adjacent, is a mock diagram of the so-called 'Baliani pump problem', showing a siphon pump connected to a pool of spring water, to the right, that pumps water over say a 17-cubit foot hill, and down to a house, below left, on the other side of the hill. According to the findings of Baliani, siphon pumps will not work past 18

cubits? Confused about this, he consulted Galileo.

The following shows a basic siphon pump, below left, as compared to Hero's syringe, both of which can be used to suck liquids up a tube:



In the Baliani situation, what they found, was that if the tube of the siphon was filled with water, by means of a pump, and then the pump was stopped, the water separated high in the tube and flowed out both ends. Galileo, after ruminating the apparent puzzle, replied back to Baliani, stating to the effect that he thought of the water column as a 'rope' that broke when sucked up past a certain height, the way a rope will break when the load gets too heavy (or the rope gets too long):

> "If hemp or steel cords break under excessive weight, what doubt could we have that a '**cord of water**' will likewise break? In fact, it will break more easily, insofar as the parts of water, becoming separated from one another, do not have to overcome resistances other than that of the **vacuum that is created at the moment of division**. This is because in the case of iron and other solids, there is a very strong and tenacious attachment of the parts that is absent in water."
>
> — Galileo (1630), "Letter to Giovani Baliani", Aug 6

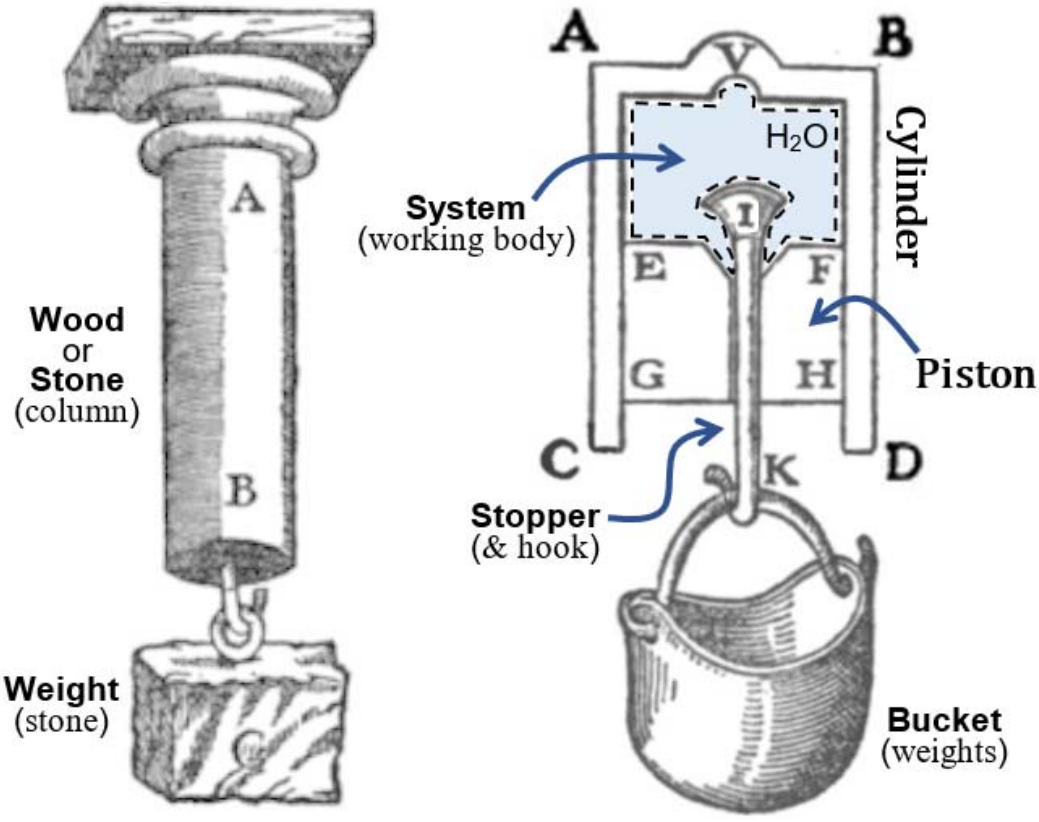
Galileo, following further rumination on this, put his ideas down into the form of a dialogue.

11.2 | Vacuum Measuring Device

In 1632, Galileo, in his *Dialogues on the Two New Sciences*, having now ruminated on the Baliani pump problem for two years, following preliminary dialogue of the possibility of 'vacuum breaking', presented a dialogue on the possibly of vacuum formation or rather the 'resistance of the vacuum' made by nature, is what stopped pumps from working past about 30 feet. His general argument was that bodies such as hemp rope, or stone or wood columns, as shown below, have a cohesive force that hold their parts together. Water, similarly, Galileo, had a cohesive force that held its parts together, but a long column of water would break, past a certain point, like a rope, when the resistance of the vacuum got to the point that the vacuum 'broke', or something along these lines. The main dialogue is as follows:[1]

> Sagredo [Baliani]: "go ahead, Salviati; assume that I admit your conclusion and show us **your method of separating the action of the vacuum** from other causes; and by **measuring it** show us how it is not sufficient to produce the effect in question."

Salviati [Galileo]: "I will tell you how to separate the **force of the vacuum** from the others, and afterwards **how to measure it**. For this purpose, let us consider a continuous substance whose parts lack all resistance to separation except that derived from a vacuum, such as is the case with water, a fact fully demonstrated by our Academician in one of his treatises. Whenever a cylinder of water is subjected to a pull and offers a resistance to the separation of its parts this can be attributed to no other cause than the resistance of the vacuum. In order to try such an experiment, **I have invented a device** [engine], shown below (right), which I can better explain by means of a sketch than by mere words.



Let CABD represent the cross section of a cylinder either of metal or, preferably, of glass, hollow inside and accurately turned. Into this is introduced a perfectly fitting D cylinder of wood, represented in cross section by EGHF [piston], and capable of **up-and-down motion** [see: reciprocating motion]. Through the middle of this cylinder is bored a hole to receive an iron wire, carrying a hook at the end K, while the upper end of the wire, I, is provided with a conical head. The wooden cylinder is countersunk at the top so as to receive, with a perfect fit, the conical head I of the wire, IK, when pulled down by the end K.

Now insert the wooden cylinder EH in the hollow cylinder AD, so as not to touch the upper end of the latter but to **leave free a space of two or three finger-breadths**; this space is to be filled with water by holding the vessel with the mouth CD upwards, pushing down on the stopper EH, and at the same time keeping the conical head of the wire, I, away from the hollow portion of the wooden cylinder. The **air is thus allowed to escape alongside the iron wire** (which does not make a close fit) as soon as one presses down on the wooden stopper.

The air having been allowed to escape and the iron wire having been drawn back so that it fits snugly against the conical depression in the wood, invert the vessel, bringing it mouth downwards, and hang on the hook K a vessel which can be filled with sand or any heavy material in quantity [weight] sufficient to finally separate the upper surface of the stopper, EF, from the lower surface of the water to which it was attached only by the resistance of the vacuum. Next weigh the stopper and wire together with the attached vessel and its contents; we shall then have the force of the vacuum [forza del vacuo]. If one attaches to a cylinder of marble or glass a weight which, together with the weight of the marble or glass itself, is just equal to the sum of the weights before mentioned, and if breaking occurs we shall then be justified in saying that the vacuum alone holds the parts of the marble and glass together; but if this weight does not suffice and if breaking occurs only after adding, say, four times this weight, we

> shall then be compelled to say that the vacuum furnishes only one fifth of the total resistance [resistenza]."

Here, then, in sum, believes that one can turn his cylinder upside down, then fill it with water, of a few inches in height, then put the piston in, then adjust his stopper hook in such a way so to let all the air out, as one compresses the piston head down, then turn his device over, then start adding weights to the bucket, one weight at a time, until that moment when the seal breaks, and the piston comes out. This, according to Galileo, would be he 'measure of the vacuum'.

In 1638, Galileo's *Dialogues on the Two New Sciences*, was finally published, delayed six years owing to political difficulties related to his trial for supporting the Copernican hypothesis, which taught that the earth goes around the sun. The immediate effect that Galileo's *Dialogues* had, in respect to furthering thought on the question of the possible existence of vacuums, and moreover the possibly of making a vacuum experimentally, was felt first in Rome, in the mind of mathematician Gasparo Berti (1639), then in Germany, in the mind of engineer and philosopher Otto Guericke (1647).

Synopsis: (add)

References

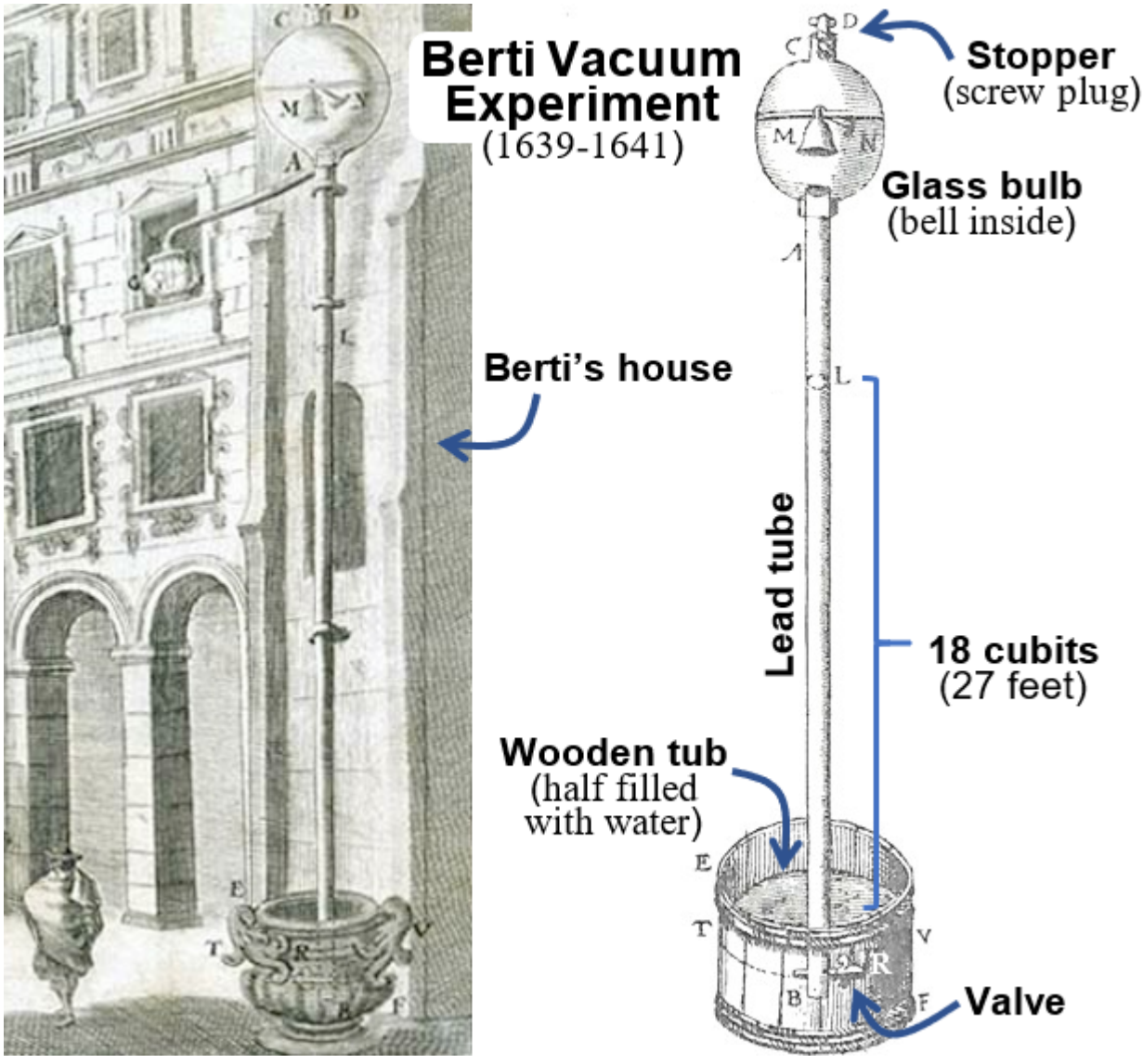
1. Galilei, Galileo. (1632). *Dialogues Concerning the Two New Sciences* (translators: Henry Crew and Alfonso de Salvio). MacMillan, 1914.

12. Berti Water Column Experiment (1639)

“.”
— Author (date), *Publication*

Chapter point: (add) [length: 12-pgs]

In Dec 1638, fifty copies of Galileo’s *Dialogues on the Two New Sciences* reached Rome, where they quickly sold out. Two men who were greatly stimulated by this publication, particularly in respect to Galileo’s vacuum measuring device thought experiment, were Rafael Magiotti, a mathematician and physicist, and Gasparo Berti, a young man who had a reputation for astronomy, mathematics, and instrument design. Magiotti, supposedly (Waard, 1938), was the one who thought up the experiment, and Berti, supposedly (Middleton, 1964), was the one who built the device, which is shown below attached to the side of Berti’s home:[1]



Here, AB is a long lead pipe, attached to the side of the house, which has a valve R at the bottom, which sits in a wooden barrel half-filled with water (note: the side tube at A, shown above left, going to a smaller vessel in window, is removed from the diagram, above right, as this was used for a second experiment).

Attached to the top of the lead pipe AB, is a large see-through glass bulb, which has an air-tight screw plug D at the top.

To perform the experiment, valve R is closed, then valve D is opened, and water is poured into, until it fills the device all the way to the top of the bulb, at location C, at which point the screw plug D is screwed in, and the device is now completely filled with water. Next is the crucial step: valve R is then opened, and the experimenters, in this case Berti and Magiotti, watched to observe what happened?

Berti and Magiotti found, when the valve R was opened, that a certain amount of water in the device, drained out, into the wooden barrel at the bottom, the height of water in the device, falling down to point L in the lead tube. The observed this height, over the course of a few days and found, supposedly, that height L stayed constant, and no more water drained out.

Next, they then closed valve R, at the bottom, and then unscrewed the screw plug D, at the top, and found that air rushed into the bulb at the top with a violent force and loud noise. The details of this part is recounted by Emmanuel Maignan who was told about the experiment by Berti, via diagrams and verbal explanation, a week after it was performed:

> "At length, when the tap R was opened the water flowed, contrary to the hope of many (e.g. Athanasius Kircher and Nicolo Zucchi), out of the pipe into the cask EF, to an easily observable height; but not all of it flowed out, and it soon stood quite still. This was clear, because a *mark was made in the cask* at the surface of the water, and next day it was found that the water in it had remained exactly at the mark although the tap R had been open all the time. Then, when this tap R had been carefully closed again, the screw D was taken out above. And as soon as it was taken out, **behold [!] the air rushed in with a loud noise, filling the space** previously abandoned by the water. Then by lowering a sounding-line, it was determined how much water was inside, or rather to what height the water stood in the tube, and it was found to stand about 18 cubits above the level of the water in the cask, at mark L."
>
> — Emmanuel Maignan (1653), *Course on Natural Philosophy*

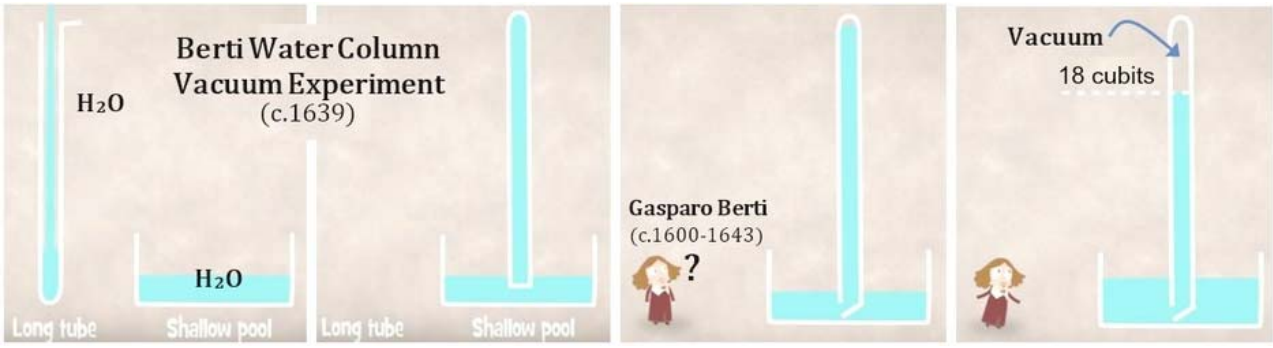
Here, to clarify, we note, after the water fell, that Berti and Magiotti made mark at the new water level in the wooden tub. Then checked it the next day to to see if it changed over the course of the night. It did not change. This experiment is Berti-Magiotti water column experiment was performed in the years 1639 to 1641.

Before leaving this section, we note that in later models of the Berti device, a bell M and bell hammer N were added to the inside of the bulb, so to test to see if sound could be heard in the purported vacuum space. To make the bell ring, inside the bulb, a magnet was brought to the outside of the bulb, near the bell hammer N, which caused it to rise, and then fall on the bell. This addition was the brainchild of Athanasius Kircher, who said it would provide definitive proof or disproof as to the existence of the vacuum (Kircher, himself, believed that it was not a vacuum).

The bell test was performed and said to have produced slight sound; although it was debated whether the sound came from vibrations of the mounting parts of the bell to the bulb. Robert Boyle, of note, repeated this acoustic experiment in a vacuum, but suspended his bell with a thin cord to eliminate this possible frame vibration effect.

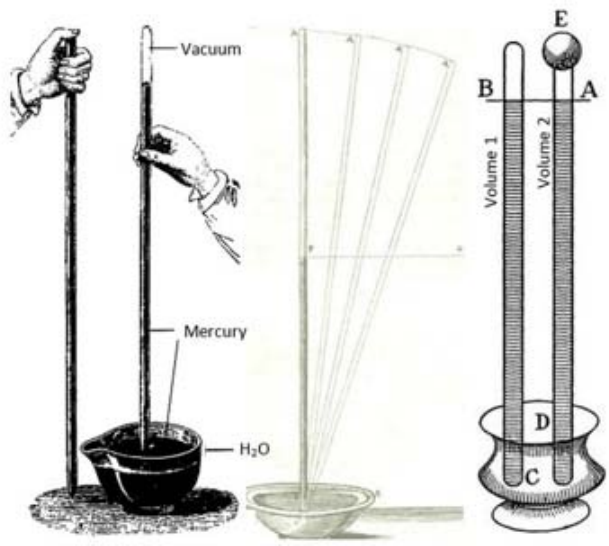
12.1 | Torricelli Mercury Column Experiment (1643)

In 1642, Evangelista Torricelli, an Italian physicist, mathematician, and former student of Galileo, succeeded Galileo as philosopher and mathematician to the Grand Duke of Tuscany. During this transition, or sometime prior, Galileo had suggested to Torricelli that he carry forward, with possible experimentation, his thought experiment work on making a device to measuring the vacuum. Prior to this, in the 1638 Leiden edition of his *Discourse on the Two New Sciences*, Galileo had suggested that if oil, mercury, or wine, were used instead of water that the vacuum would break at a different column height. In this period, between 1639 and 1643, Torricelli was also informed by Rafael Magiotti about the Berti water column experiment, about which Torricelli envisioned the experiment occurring as follows:

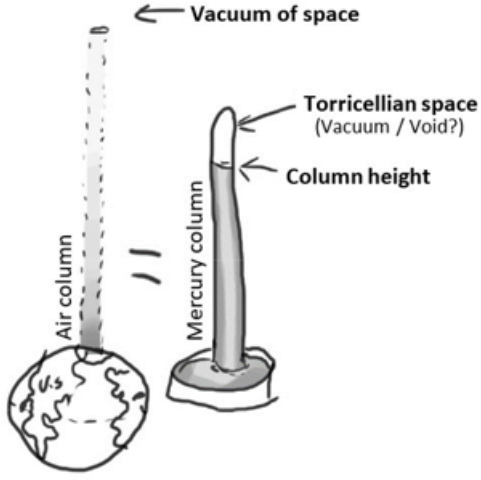


Accordingly, Torricelli, knowing that mercury was 14 times heavier than water, which some have said was suggested to him by Galileo, reasoned that if he used mercury, instead of water, in the Berti experiment, and used a glass tube, instead of the lead-glass design used by Berti, that he the new scaled down model should find the mercury column stopping at an L height of about 76 centimeters.

Torricelli then communicated this proposal to his friend Vincenzo Viviani, also another former student of Galileo, now being a student of Torricelli's, who then, it is said, made the glass tube, procured the mercury, and performed the following experiment, supposedly per the instructions of Torricelli:



In conducting this experiment, Viviani filled a glass tube, about 80 centimeters in length, with mercury, all the way to the top. He then placed his thumb on the top open end of the filled tube, so to make the vessel air tight. Viviani then upended the tube into a large tub filled half way with mercury, and then released his thumb. As predicted by Torricelli, the column of mercury fell to about 76 centimeters or an 'ell and a quarter and a finger or more', as it was originally reported. Torricelli, upon hearing of Viviani's experimental success, then went on himself to do the experiment in a variety of ways.



In Jun 1644, Torricelli, in his now-famous letter to Michelangelo Ricci, declared that air was an ocean layer on the surface of the earth:

> "We live **submerged at the bottom of an ocean** of elementary air, which is known by incontestable experiments to have weight, and so much weight, that the **heaviest part near the surface of the earth** weighs about one four-hundredth as much as water."
> — Evangelista Torricelli (1644), "Letter to Michelangelo Ricci"

Torricelli, in this letter, also described how used two tubes of different volumes, C and D, as shown above middle, yet the height of the mercury remained the same, therein disproving the conjecture that there was some 'rarefied stuff' (e.g. Cartesian subtle matter) in the top volume (that the level BA remained the same, despite the two volumes,

disproved the rarefied stuff objection). In a second experiment, Torricelli, explained how he floated a top layer of water above the mercury, such as shown above left, and that when he raised the tube to the water/mercury level divide, that water rushed in, with great violence, and filled the voided region, therein 'proving' that the top was, in fact, empty, i.e. a vacuum.

Torricelli also, of note tried putting fishes, large flies, and butterflies into the so-called space above the mercury column, a space now tending to be called the 'Torricellian space', so to test whether they could 'live', make sounds, or fly in a vacuum? He found, however, that they were too much affected by passage of going up through the mercury, before entering the Torricelli space, for the experiment to be satisfactory. We will not shortly that Robert Boyle, who came to hear about these experiments in the mid 1650s, was the one to first successfully try out this tests.

12.2 | Mersenne (1645)

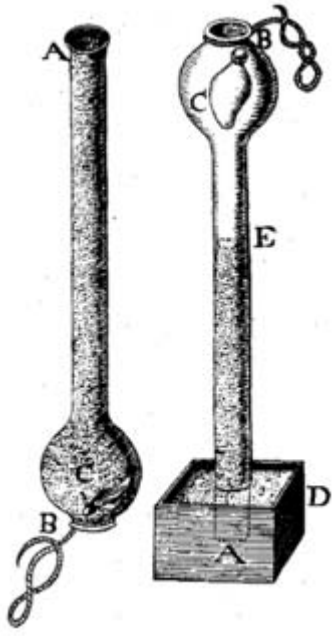
In 1644, Michelangelo Ricci, Torricelli's communication conduit, sent Marin Mersenne, a French Cartesian theologian, philosopher, mathematician, known as Europe's 'leading publicist of scientific information', extracts of Torricelli's letters on his vacuum experiments. In 1645, Mersenne visited Florence and attended a demonstration of the Torricelli experiment, and also visited Rome, where he had discussions with the major participants in the Italian vacuum researches.

In Mar 1645, Mersenne, upon his return to France, published information on the Torricelli vacuum experiments, which worked to transmit this new information to England, Holland, and Poland.[4]

In Oct 1646, Pierre Petit, a French astronomer, physicist, mathematician, and instrument maker, presumably per influence of the news reports of Mersenne, performed the first Torricelli experiment in France.[4] This event, in turn, sparked a wave of vacuum research in France.

12.3 | Roberval Carp Bladder in Vacuum Experiment (Jun 1648)

In c.1647, Gilles Roberval, a French mathematician, physicist, and experimentalist, who had been part of 'Mersenne's circle', which included Blaise Pascal, since 1628, had begun the testing of putting birds and mice into the so-called Torricellian space or proposed vacuum region above the mercury; the general theory being based around at the time being that the mercury column balanced a column of air going up to the top of the atmosphere, as shown adjacent.



In May to Jun 1648, Roberval performed his publicly astonishing carp swim-bladder in a vacuum experiment, wherein he took the swim bladder of a carp, deflated it, tied the opening of it in a knot, then put it into a Torricelli tube, inverted the tube, wherein the Torricellian space would form, with the bladder in this space, after which the bladder would begin to expand, to the astonishment of onlookers. The reason for this being that the few particles of air, in the previously deflated bladder, when inside of a vacuum, began to expand outward, having no atmospheric pressure to keep them compressed.[4]

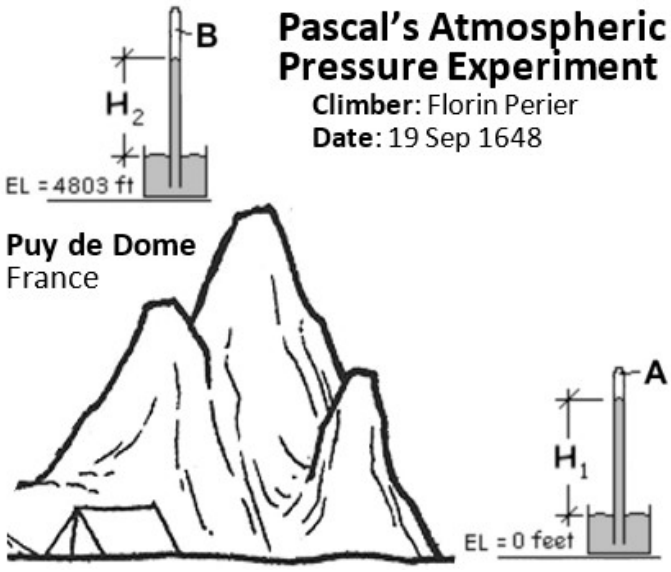
12.4 | Pascal Atmospheric Pressure Experiment (Sep 1648)

In c.1647, Blaise Pascal, the intellectually precocious physicist, mathematician, and philosopher, after hearing about Torricelli's experiment, with the mercury column, from Marian Mersenne, and Torricelli's idea that we 'live submerged at the bottom of an ocean' of air, became absorbed into thought about ways to test this new theoretical proposal.

Ruminating on the implications of this new view, based and experiments with this new mercury column device, particularly that the implication that the atmosphere has weight and that the heaviest parts of this ocean of air reside near the surface of the earth, Pascal came to the conclusion that someone needs to carry a Torricelli mercury column to the top of a mountain to evidence this proposition for their own eyes. Pascal, in short, reasoned that the column of mercury would be lower at the top of the mountain, because the lighter parts of the atmosphere reside there.

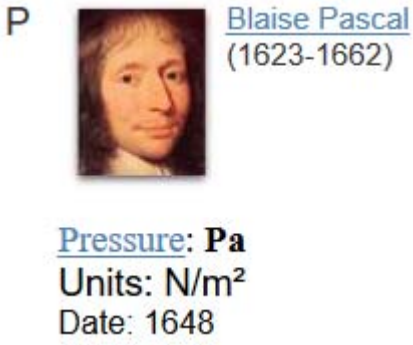
Pascal, accordingly, communicated his proposition to his brother-in-law Florin Perier in the following letter, with the suggestion that Perier do the climb, per reason that Pascal's health was too poor to make the climb himself:

> "I have thought of an experiment which will remove all doubt, if it be executed with exactness. The experiment should be made in vacuo several times, in one day, with the same quicksilver, at the **bottom and at the top of the mountain of Puy**, which is near our town of Clermont. If, as I anticipate, the height of the quicksilver be less at top than at the base, it will follow that the weight or pressure of the air is the cause of this; there certainly is more air to press at the foot of the mountain than at its summit, while one cannot say that nature abhors a vacuum in one place more than in another."
>
> — Blaise Pascal (1648), "Letter to Florin Perier"



On 19 Sep 1648, Perier made the climb, a total of 4,800-feet, which is the equivalent of three Sear's Towers, during which he recorded the height of the mercury column at first the base and then top of Puy de Dome, finding that the column of mercury fell by 3 inches and 1.5 lines, as predicted by Pascal. Perier described things as follows:

> "At eight o'clock, we met in the gardens of the Minim Fathers, which has the lowest elevation in town. First, I poured 16 pounds of quicksilver into a vessel, then took several glass tubes, each four feet long and hermetically sealed at one end and opened at the other. Then placed them in the vessel of quicksilver. I found the quicksilver stood at 26" and 3½ lines above the quicksilver in the vessel. I repeated the experiment two more times while standing in the same spot. They produced the same result each time. Taking the other tube and a portion of the quicksilver, I walked to the top of Puy-de-Dôme, about 500 fathoms higher than the monastery, where upon experiment, and found that the quicksilver reached a height of only 23" and 2 lines. I repeated the experiment five times with care. Each at different points on the summit, found the same height of quicksilver, in each case."
>
> — Florin Perier (1648), "Notes on Puy de Dome Climb Experiment", Sep 19



Herein, then, was the definitive proof that the atmosphere has weigh, that the heavier part or weight of the atmosphere, occurred at the surface of the earth, and that this pressure or atmospheric pressure decreased with altitude.

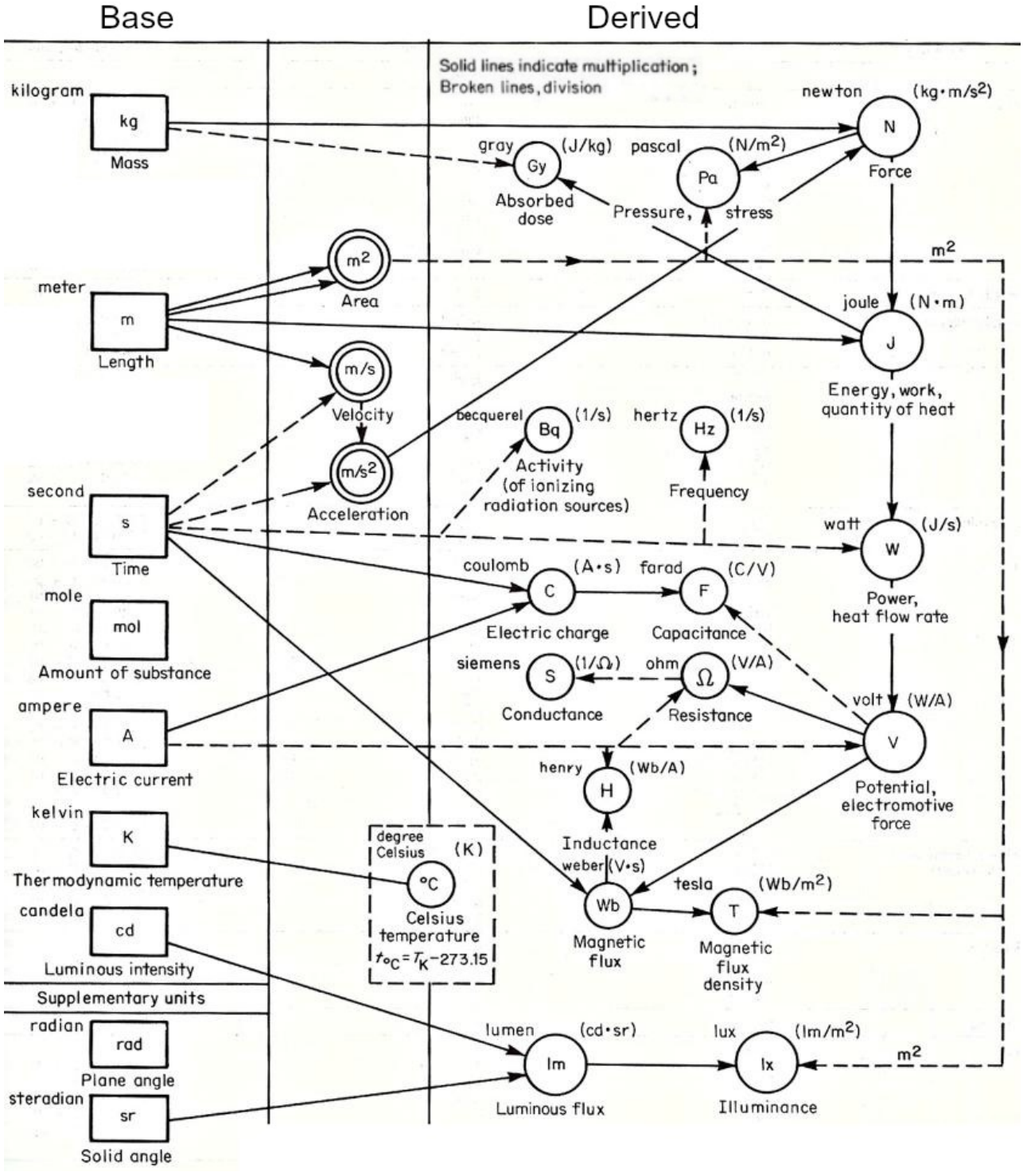
12.5 | Unit of Pressure | Pa = N/m^2

The units employed the physical sciences, in the early centuries of their development, tended to vary per country, leading to much conversion and symbol confusion. In 1960, an international system, or *system international* (SI), in French, i.e. an 'SI unit' system, was established, and developed over the years, via a number of international conferences, which is a decimal and metric system, that has seven base units: mass (kg), length (m), time (s), amount of substance (mol), electric current (A), thermodynamic temperature (K), and luminous intensity (cd), from which a number of 'derived units' exist, with special names. The first of these derived units, chronologically speaking, in respect to the history of thermodynamics, is the unit of pressure.

In 1971, during the 14th General Conference on Weights and Measures, name 'pascal', in honor of Pascal and his mountain climbing experiment, was adopted for the SI unit 'newton per square meter' (N/m^2), a unit thus defined as, with its derived units, as follows:[6]

$$1\,\mathrm{Pa} = 1\,\frac{\mathrm{N}}{\mathrm{m}^2} = 1\,\frac{\mathrm{kg}}{\mathrm{m}\cdot\mathrm{s}^2} = 1\,\frac{\mathrm{J}}{\mathrm{m}^3}$$

where N is newton, the unit for force, and J is joule, the unit of energy. We will devote short historical sections, as we have done here for Pascal, for each of the main units and derived units and variables of chemical thermodynamics, as we progress. The following table, from the 1976 US National Bureau of Standards, shows relationships between the SI base units and derived units:



Here, in respect to this unit table, it important to remember, that human chemical thermodynamics, i.e. thermodynamics applied socially, economically, historically, philosophically, etc., that the units one to defined social phenomena, reactions, and processes HAVE to in base units or derived units or generally

measurable experimentally based units that can be reformulated into SI base units. SI units applied socially is a very complex and yet fully worked out subject to say the least. Keep in mind, however, that the aim is to reduce all of social phenomena into the ten main thermodynamic variables, which combined to yield a function *characteristic* of the social system, as shown by the characteristic function notation table in the preface to this work.

While some of these units applied socially are intuitive and easier to grasp conceptually, others are still beyond the grasp of full understanding. Take the unit 'pascal', for example, or force per unit are, or N/m^2. When in war times or war films we hear the phrase *reconnaissance in force*, this is defined, according to the US Department of Defense's *Dictionary of Military and Associated Terms* (2005), as 'an offensive operation designed to discover and or test the enemy's strength or to obtain other information'. Here, the 'force', in newtons N, consists of the armed troops, ready to employ gunfire. The 'area', in square meters m^2, consists of the successive two-dimensional walls, physical or geometrical, that the troops encounter or must pass through. Given some GPS tracking data and some further thought on this, one can quite readily formulate military pressures of different locations in SI units of pascals.

We bring this up, at this point, owing to the fact that in the history of top 500 published attempts to apply thermodynamics socially, economically, or to the humanities generally, there have been some rather inane attempts to basically throw out the entire SI unit system and invent baseless nonsensical units. Among these, three types tend to be found.

First, is the *letter rhyming derivation system*, wherein the author takes a given unit from the SI table, such as 'P' for pressure, 'V' for volume, or 'T' for temperature, and simply keeps the first letter, and reinvents the unit, by making it rhyme with some key term from the subject matter in question, e.g. U of internal energy of thermodynamics becomes the U of utility in economics, simply because they have the same symbol? In economics, to go through one example, using John Bryant (2010), as a case in point, in respect to a monetary systems, we find statements such as P is 'Price' level of a commodity, V is the 'Volume' output of the commodity, and T is the 'Trading' level of the commodity in the stock market, and these can be combined to make an economic 'ideal gas law' equation of state, and that this is a 'thermodynamic approach to economics'.[7] This, correctly, however, is NOT a thermodynamic approach.

Second, we sometimes will come across a number of so-called *unitless thermodynamics* varieties, wherein authors will attempt to employ thermodynamic units to make some argument, but either will not use actual units or will invent new terms, which they say are related to thermodynamic variables. One example being Ivan Kennedy's 2001 version of 'biothermodynamics', wherein he introduces the concept of 'action', which he defines as a unitless thermodynamic property related to entropy, resulting from impulses of energy on matter producing force, based on his blurry conception of the conservation of momentum, and uses this as so-called unified theory.[8] This, likewise, is not a thermodynamic approach.

Thirdly, is the so-called *information unit thermodynamics* method. This originated via an inside joke. In 1940, Claude Shannon, an electrical engineer, who had never studied thermodynamics, asked John Neuman, a chemical engineer, who had studied thermodynamics, what name he should give to his new formula for information transmitted, via 1s and 0s in telegraph wires, which happened to be a formula of the form $x = y \log z$, stemming from Ralph Hartley's 1928 paper 'Transmission of Information'? Shannon at the time was thinking of calling it the name 'uncertainty', thematic to the Heisenberg uncertainty principle. He asked Newman about this, and Neumann laughed and said, knowing that Max Planck in 1901 had formulated a gas theory model of entropy using a similar type of logarithm, that he should call his new information transmission formula by the 'same name', per reasoning, in Neuman's mind that 'nobody knows what entropy really is', so that accordingly, 'you will always win, in any argument, should one arise'.[9]

Many, accordingly, have confused the two fields of study, computer science and thermodynamics, and have come to believe that *entropy* of thermodynamics, which has units of joules per kelvin J/K, has units of bits. Many become lured into this snare, for some peculiar reason. The apex example of unit confusion in this area is Arieh Ben-Naim, an Israeli chemist, who actually completed his PhD on 'Thermodynamics of Aqueous Solutions of Noble Gases', who in the last decade or so has published a slew of books, arguing that the entire SI unit table should be reformulated in terms of binary digits or bits. The subject is so-confused in this latter area, that students go to PhysicsForums.com and query: 'Why is there not SI unit for Information?' (2017). There is even an entire online journal named *Entropy*, founded in 2009 by Chinese chemist Shu-Kun Lin, who was confused about the various so-called 'types' of entropy, devoted to a proliferation of this confusion.

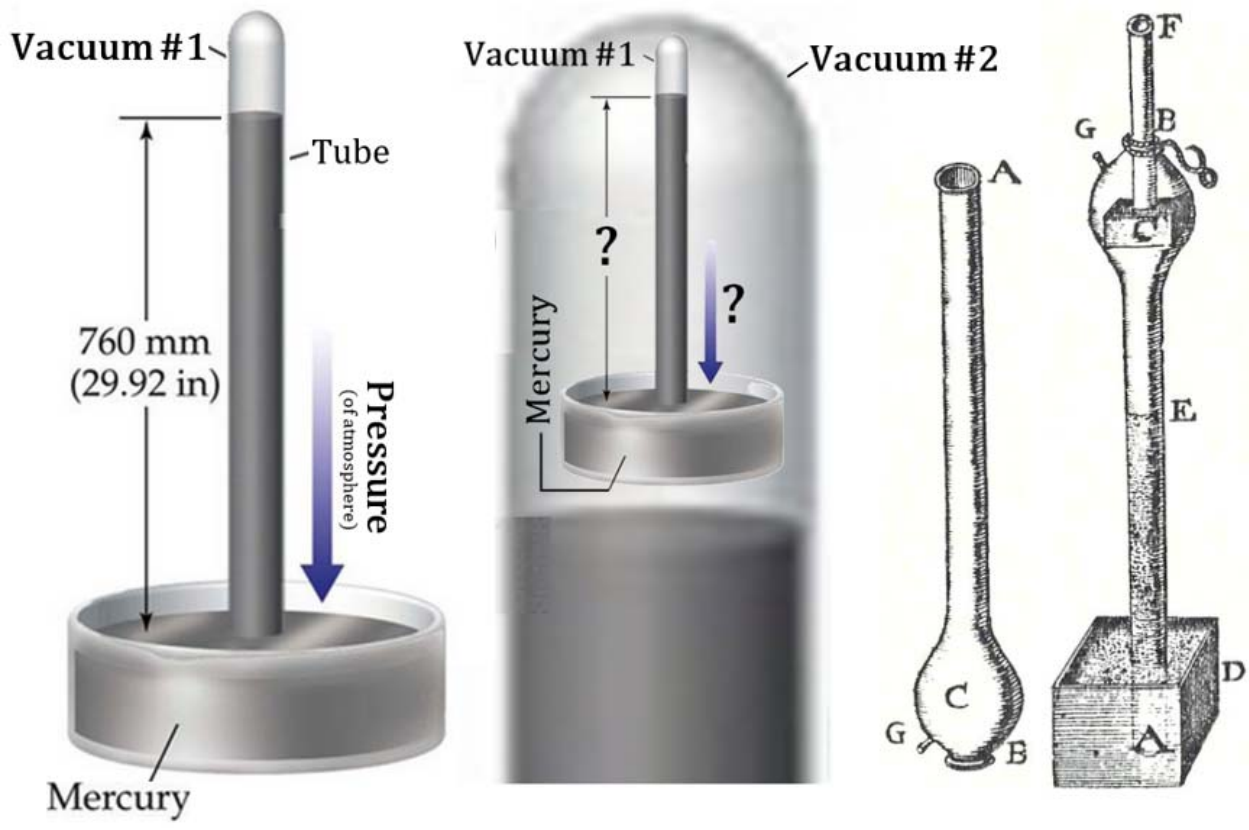
The concluding point, to keep in mind, here, is that theories and formulations, in regards to chemical thermodynamics applied to the humanities, are SI unit based, or approaching these units, e.g. mol is difficult to formulate in social terms, per reason that the human population is below the 10^{23} molecule level, then one is off-base, literally speaking, i.e. off base in their base units.

12.6 | Void with a Void Experiment (c.1649)

To continue, one of the more curious vacuum experiments, that arose from these Italian and French researchers, was the famous 'vacuum with a vacuum' or void-within-a-void experiments, where a small Torricelli barometer was put inside of another larger Torricelli barometer. The general idea here being that if the weight of the atmosphere was holding up the mercury column, then to test this conjecture, if one could eliminate this surrounding atmosphere, around the outside of the tube, i.e. by turning it into a void also, then the column of mercury in the inner tube, should then fall to the same level as in the bottom basin of mercury.

The actual person who first did or thought up this void in void experiment is a bit inexact, as is the case with much of the early history and dates of vacuum research. The standing consensus, is that Torricelli, in his second letter to Ricci, that Mersenne received a copy of, had suggested the vacuum within a vacuum experiment, and also should be expected if the experiment should be tried.[5]

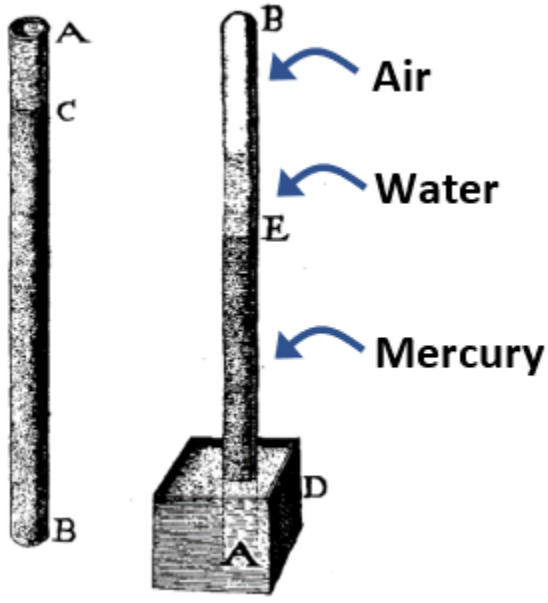
Next, it is said that Pascal 'tried' this experiment; presumably after he had he had completed his mountain climbing experiment.[5] We also note that Robert Boyle (1659), when he does the vacuum in vacuum experiment, in his receiver vacuum bulb, credits Pascal as having been the first to perform this experiment. Thirdly, it is said that Roberval 'devised' a vacuum within the vacuum experiment, but never described the apparatus.[5] Lastly, Adrien Auzout, a French astronomer, according to Jean Pecquet, who in his 1651 *New Anatomical Experiments*, popularized, for the world, all the aforementioned French vacuum experiments, was the one who gave the 'first successful' trial of the vacuum in vacuum experiment, as diagrammed by Pecquet below right, or as illustrated, in a focused detail, below middle:



This particular experiment would later attract the attention of Robert Boyle (1559), whose work attracted the attention of Christiaan Huygens (1661) who both repeated this experiment in vacuum receiver bulbs, which in turn stimulated much philosophical debate, going into the 1670s.

12.7 | Pecquet (1651)

In 1651, Jean Pecquet, in his *New Anatomical Experiments*, as touched on, presented a popular summary of the previously discussed Italian and French vacuum experiments, such as Roberval carp bladder experiment and the void-with-in-void experiment, but with the addition of his 'experiment #4', which was either performed by Pecquet or more likely someone before him, which shows equal volumes of water E and air B placed above mercury AE, in a tub of mercury D.



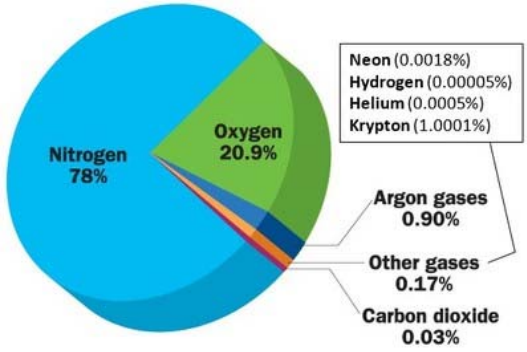
This demonstrates, according to Pecquet, that air exerts pressure by virtue of its elasticity, whereas water exerts pressure by its weight. Pecquet's book was translated into English in 1653, and therein became one of the main conduits of knowledge about vacuum experiments to the English-speaking world, reaching the minds of Henry Power and Robert Boyle. Pecquet's experiment #4 attracted the mind of Power, in whose mind, it is said, stimulated the experimental derivation of Boyle's law (or Power's law). The vacuum in vacuum and bladder experiments were later repeated by Boyle.

12.8 | Social Pressure and Barometers

In respect to the Torricelli barometer, the 'pressure' that is measured, technically, is the average *force per unit area* of the impacts of the kinetically moving air molecules of the atmosphere, which are predominately the chemical species of nitrogen N_2 (78 percent) and oxygen O_2 (21 percent), along with another one percent of rarer gases, as shown adjacent. Moreover, the force per unit area, as Pascal evidenced in his mountain climb experiment, is greater near the surface of the earth, as compared to higher elevations, such as on the top of the mountain. In simple verbal descriptive terms:

> "The higher we go in the air, the less heavy it is."
> — Giovani Baliani (1630), "Letter to Galileo"

In physics terms, we know the reason behind this observed effect is that each molecule of air, say one molecule of nitrogen N_2, with mass m_2, will attract toward the earth, of mass m_1, with a force of mutual attraction, as defined by the following formula, called Newton's law of universal gravitation:



$$F = G\frac{m_1 m_2}{r^2}$$

where r is the radius of separation between the gas particle and the earth, and G is the universal gravitation constant. Accordingly, the higher we go up the mountain, the greater the radius r of separation becomes, and hence the smaller the average force per unit area becomes, whereby the pressure, defined as shown below, or atmospheric pressure, decreases:

$$p = \frac{F}{A}$$

Now, this is all relatively straightforward, as modern basic physics explains this.

When, however, this very same logic is scaled up and applied directly to the question of social force, social force per unit area, and attempted quantitative measure of social pressure, is when things become greatly confused, as cartooned adjacent. The following quote, will help to put things into clearer perspective:

> "The deeper the liquid is, the more it will compress the deeper parts; for they are compressed both by the **upper parts** [vertical pressure] and by those **next to them** [lateral pressure]."
>
> — Niccolo Tartaglia (c.1545), *Jordanus: a Small Treatise*

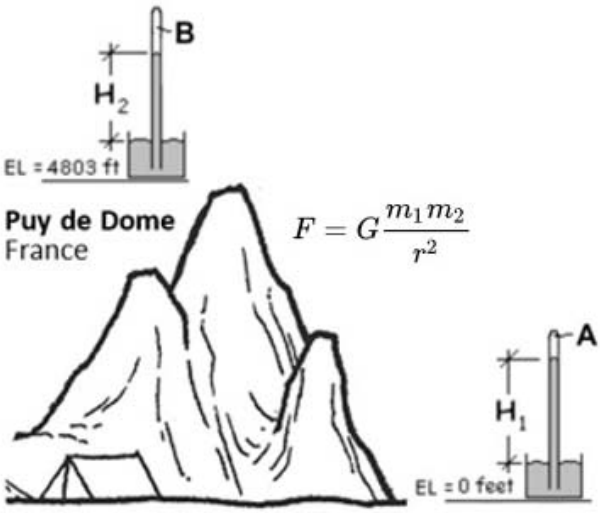
In this light, we see that humans—differing in some sense from nitrogen N_2 or oxygen O_2 gas molecules, which are able to move in three dimensions, or liquid mercury Hg, which basically just flow along the surface, clinging to itself—are types of powered chemical species, attached to a surface (earth's surface), that move laterally, and therein, accordingly, will be compressed both by the 'upper parts', the weight of the atmosphere, to which we are accustomed to by long periods of evolutionary development, but also compressed by 'those next to them', namely those neighboring humans, or human molecules, next to them.

Now, the social pressure, as was introduced, tersely in the Social Piston and Cylinder Engine section (§7.2), in reference to the view that humans, viewed as particles or molecules, on one side of a given social piston boundary, e.g. territory boundary, a certain cafeteria table in high school, the boundary of a country, etc., will bang or collide with that surface, with a force per unit area, or pressure P_1. Likewise, the human particles on the other side of the exact same social piston boundary, in a similar manner, will bang on or collide with that surface, with a force per unit area, or pressure P_2. If one pressure, say P_2, is greater than the other pressure, P_1, then the piston will adjust, the social boundary will be moved.

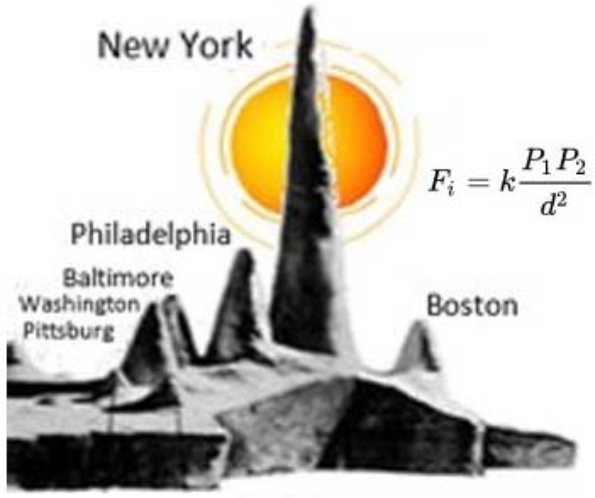
This said, data on social gravitation models are far behind that which is established for universal gravitation models, to say the least. Nevertheless, we do, however, have a working outline and some general formulas, based on roundabout data measurement. The following, in this direction, is an oft-cited quote on the subject of social gravitation:

> "The great law of molecular gravitation: **man tends of necessity to gravitate toward his fellow man**. Gravitation is here, as everywhere else in the material world, in the direct ratio of the mass and in the inverse one of the distance. The greater the number collected in a given space, the greater is the attractive force there exerted, as is seen to have been the case with the great cities of the ancient world, Niniveh and Babylon, Athens and Rome, and is now seen in regard to Paris and London, Vienna and Naples, Philadelphia, **New York**, and Boston.."
>
> — Henry Carey (1858), *Principles of Social Science, Volume One* (pgs. 42-43)

Likewise, the following compares the Pascal mountain climbing experiment (1648) with the plaster model of population potentials made by William Warntz, an American demographer, based on equations formulated by physicist John Q. Stewart:[3]



Newton-Pascal Atmospheric Pressure Model
(1648)



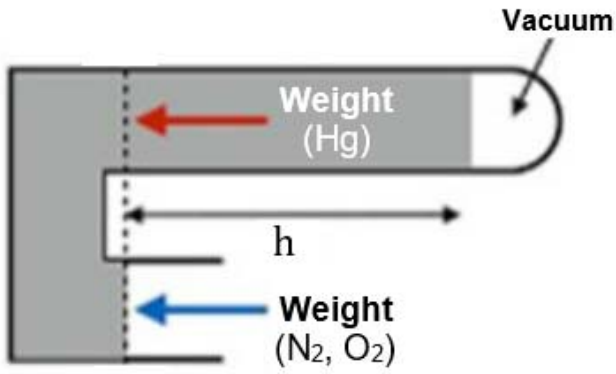
Stewart-Warntz Social Gravitation Model
(1964)

The force F_i of interaction, as measured by things such as number of telephone calls, traffic flows, mail, etc., between one city or social mountain, say New York, and another city, say Pittsburg, in the Stewart-Warntz model (1964), was found, based on demographic data, to be proportional to the product of the populations of each city, P_1 and P_2, and the inverse of their distance of separation squared d^2.

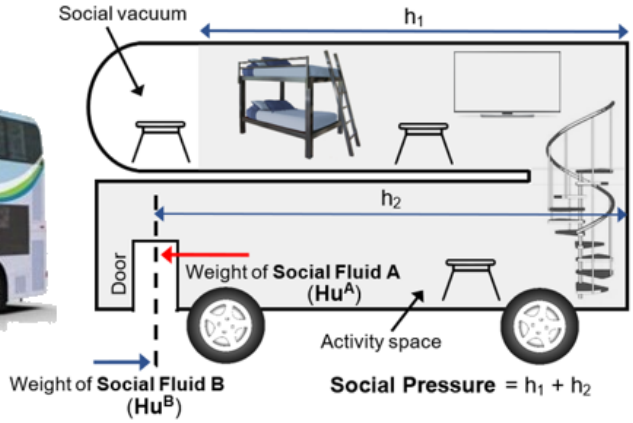
Here, accordingly, barring prolonged digression into the pros and cons of the Warntz-Stewart model, we will simply point out, based on this general social gravitation model, that as one climbs the social mountain of New York, though we presently lack a social barometer able to gauge this type of pressure, the height of the social 'mercury-like' column, if we are to construct one, will *rise* the closer one gets to the apex of New York.

In this direction, in respect to proto-models of social barometers, the following shows a packed double decker bus in Tokyo, below left, as compared to a Torricelli mercury barometer, turned sideways, below right:

Bus in Hong Kong



The following, accordingly, shows a draft model of a MTV 'Real World' style double-decker bus, rebuilt to act as a social barometer, able to drive up and down social mountains, and therein gauge a crude measure, at a first approximation, of social pressure, similar to what Pascal did with atmospheric pressure:



In its most basic conception, to test this social barometer, one would set up a social experiment, akin to the MTV's famous Real World television series, in which a group of college students were recruited to reside or 'live' (exist) on double-decker tour bus / mobile home of sorts, under the 'overt pretext' that the goal of the show was to record their goings on, as they visited various cities.

In this manner, the mercury social molecules would be made to cohere, like actual mercury atoms in liquid mercury, per some type of pre-arraigned lucrative financial binding agreement. In the public double-decker scenario, the mercury like social molecules on the packed buss would, invariably be exchanging into and out of the society, which is thus not a true Torricelli barometer.

The bus would be equipped with all the basic amenities of a home, e.g. bed, kitchen, study room, recreation room, tables, seats, etc., arranged in such a way that the far-most back section of the bus, when not occupied with the participants or chemical species, would signify the size of 'social vacuum', and the where the activity space, where people are actually found, varying per city, represented by $h_1 + h_2$ above, would represent the height of the social mercury column or quantitative measure of the social barometer.

One should find, just as predicted by Pascal, that the closed end, i.e. social vacuum space, of the U-shaped social system, would *decrease* as the U-shaped social system was moved *towards* large mountainous cities, e.g. New York or Tokyo, meaning the force of the social pressure of these large central cities would work to move more of the mercury-like humans farther up or back into the bus, on average, the big cities being akin to the earth in the Pascal scenario. Secondly, one should find that the size of the social vacuum should *increase* as one moved away from New York, e.g. towards small towns, with little populations; or equivalently the hypothetical height *h* of the U-shaped social system would be found to *decrease* as one climbed away from New York, because there would be less social mass pushing on the mercury like social system.

Synopsis: (add)

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7. http://www.eoht.info/page/Letter+rhyming+derivation+method
8. http://www.eoht.info/page/unitless+thermodynamics

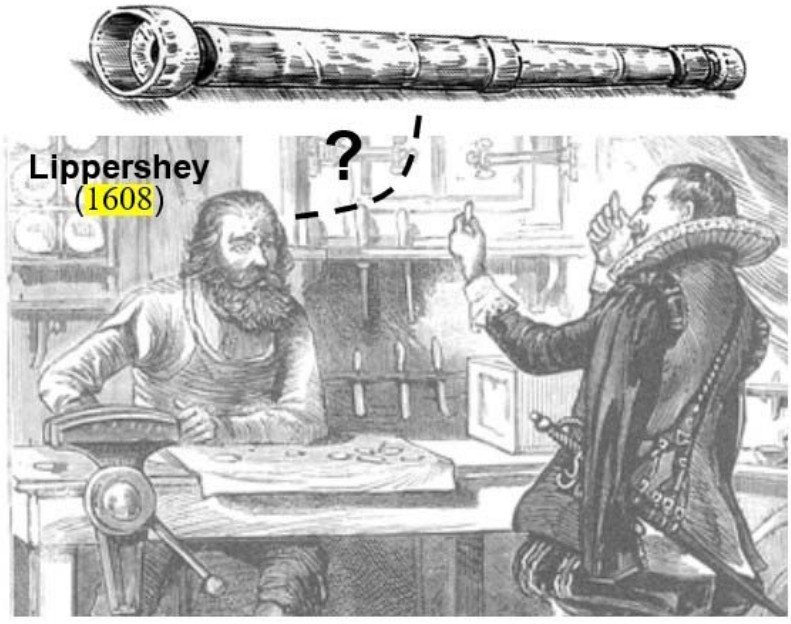
9. http://www.eoht.info/page/Shannon+bandwagon
10.

13. Guericke (1647)

"Void means an absence of things."
— Giordano Bruno (1584), *On the Infinite Universe and Worlds* (pg. 10)

Chapter point: To introduce the peculiar mind of Otto Guericke, who is the anchor genius, in thermodynamics, in respect to the question of vacuums, piston and cylinder volumes or spaces, and the ability or power of the vacuum, such as to lift several thousand pounds in the air [length: 12-pgs]

In 1608, Hans Lippershey, a German-born Dutch spectacle maker, after observing one of his customers one day looking through two lens, one convex the other concave, one in front of each other, as shown below, took two such lenses, in the weeks to follow, and arranged them inside of a tube, and therein invented the telescope, or device for 'seeing things far away as if they were nearby', as he put it in his patent, which he applied for in Oct of that year:

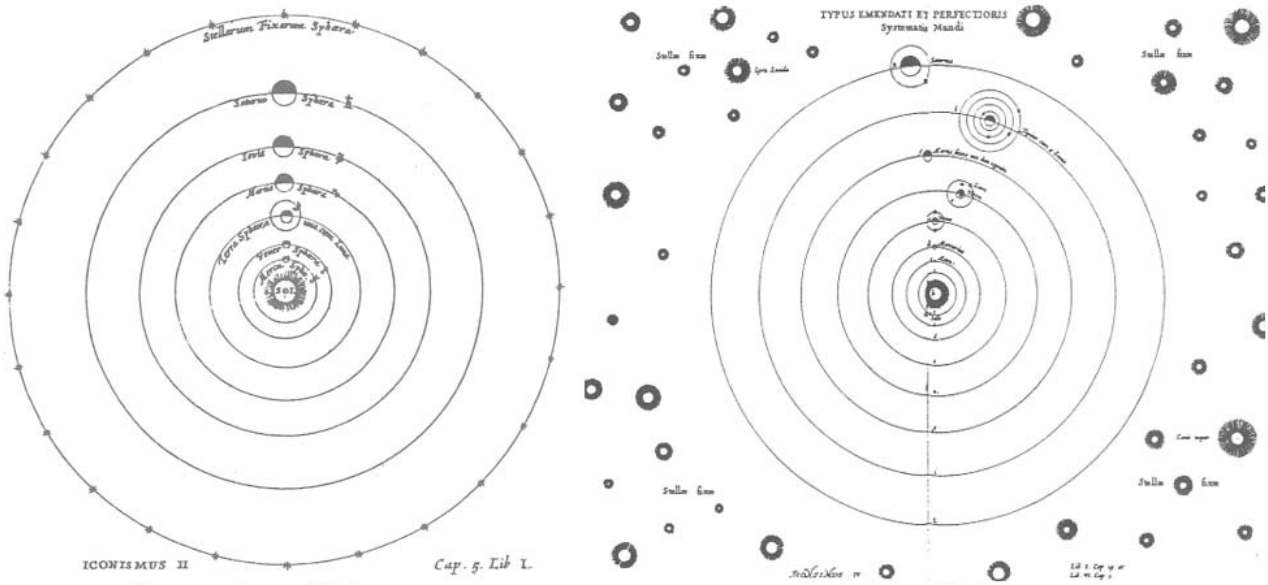


By Jan 1610, news of Lippershey's new so-called 'Dutch perspective glass', as it was then been called, reached the ears of Galileo, as we have mentioned, who then proceeded to make his own version of what Lippershey had built. The result, shown in the photo above, was a hand-held tube that allowed one to see things at a resolution 30x that of the eye. On 13 Mar 1610, Galileo, in his *Message on the Fixed Stars*, presented to the world, the first published scientific work based on observations made through a telescope, detailing observations of the imperfect and mountainous moon, hundreds of stars that were unable to be seen in either the Milky Way or certain constellations with the naked eye, and moons that appeared to be circling Jupiter.

In 1611, Johannes Kepler, having, like Galileo, built his own telescope, penned *Dioptrice*, a treatise on the principles of telescopes. In the decades to follow, telescopes were being built and used, throughout the world. An immediate repercussion of this new instrument, was its impact on philosophy.

In 1640s, in Germany, the invention of the telescope, had transformed the previous Copernican model (1543) of the universe, made via naked eye measurements, as shown below left, wherein the so-called 'fixed stars' are all presumed to be *fixed* as points in space on an immobile sphere or vessel boundary, as Aristotle would have it, to that wherein the previous fixed stars, were no longer so fixed, and seemed, per the new telescope date, to be separated from each other and from the earth and the sun, by seemingly great distances, as shown below right, in the new Guericke model (1647) of the universe, as juxtaposed by Otto Guericke, a German engineer, physicist, natural philosopher, mayor, and diplomat, in the opening chapter 'The System

of the World, According to the More common Philosophical Theories', of his 1672 magnum opus *New Magdeburg Experiments on the Vacuum of Space*:[5]



Here, in comparing these two respective cosmologies, left, *pre*-telescope cosmology, right, *post*-telescope cosmology, that the previous sphere or circle of 'fixed stars', namely the seventy ring, with the star asterisks placed on it, has been usurped by a scattering of stars, of various sized, placed at various distances from the sun. This new view of things, in the mind of Guericke, opened up an entirely new consortium of philosophical questions, in respect to the previously purported 'void' or *vacuum* of space or place, said by Aristotle, to be the vessel of the solar system?

In retrospect reflection on this new mind-sweeping view of things, Guericke, in his chapter section 'How the Author was Led to Investigate the Vacuum', says the following:

> "Since I had deliberated on these questions for a **long time** and likewise been engaged in active study of the structure of the world, not only did the great mass of these world bodies and their enormous distances lead me to doubt that human intelligence cold comprehend them, but also, and most particularly of all, did vast, intermediate, and endless space fill me with curiosity and infuse me with a desire to investigate it. For indeed, what is it? Inasmuch as it contains all things, it serves as a place for 'being' and 'existing'. Is by change some fiery heavenly matter? Is it solid, as the Aristotelians assert? Is it fluid, as Copernicus and Tycho Brahe believe? Is it some sort of tenuous fifth essence? Or, is space completely devoid of all matter, a 'vacuum', as it were."
>
> — Otto Guericke (1672), *New Magdeburg Experiments on the Vacuum of Space* (pg. 84)

Guericke, following this telling quote, wherein he references 'desire', the most powerful agent in the human sphere of operation, goes on, in his chapter two: 'Space and Time', to an historical digression on Aristotle's ideas on 'place'. Firstly:

> "Because philosophers commonly state that a 'vacuum' is a *place* in which there is nothing, it will be necessary to say something about place. What, indeed, is it?"
>
> — Otto Guericke (1672), *New Magdeburg Experiments on the Vacuum of Space* (pg. 84)

Next, the established Aristotelean definition:

> "Aristotle defines the concept of '**place**' as a kind of 'immobile container or receptacle which holds another body', or 'bounds of that which is contained and is in contact with it', or the 'outermost bounds of that which is contained'."
>
> — Otto Guericke (1672), *New Magdeburg Experiments on the Vacuum of Space* (pg. 84)

Said another way:

> "We usually locate everything in some 'πόυ' (where), i.e., in a particular 'region' or within some ***boundary***. This is what we call place."
>
> — Otto Guericke (1672), *New Magdeburg Experiments on the Vacuum of Space* (pg. 85)

Here, to pause, we see the term 'boundary', one of the top, albeit greatly confused, terms in the arsenal of the modern chemical thermodynamicist. The idiot thermodynamicist, as has so-often been regurgitated, will simply tell like to proclaim that there are three boundaries: open, closed, and isolated.

Guericke, then jumps to his chapter on 'Empty Space', wherein he tells us, via a great deal of learned via experience wisdom:

> "An empty place or *vacuum* is the cause of a very great effect in nature."
>
> — Otto Guericke (1672), *New Magdeburg Experiments on the Vacuum of Space* (pg. 86)

This overly-accurate and discerning statement cannot be overemphasized enough. He continues:

> "Experiments, described in subsequent chapters, visually demonstrate an exaggeration of this characteristic, when air or water, enters evacuated glass vessels, surging in with **great force**, contrary to the usual *course of nature*."
>
> — Otto Guericke (1672), *New Magdeburg Experiments on the Vacuum of Space* (pg. 86-87)

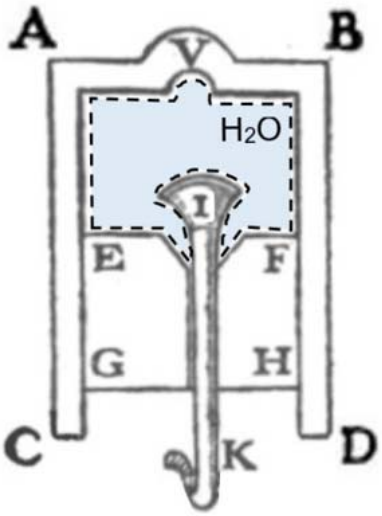
Here, to pause, will be digressed on repeatedly and pointedly, in the chapters to follow, we seen, the outline of experimental evidence, *contrary* to the 'usual course of nature', subtle, but revolutionary notice, so to say, of new vacuum-based view, that what one, historically, has considered as 'natural' or 'unnatural', or good and bad, in anthropomorphic religio-mythology speak, is no longer a matter of black and white, or something divined by prophets, but rather something *measurable* by experiment. The following quotes, all anchored to the preface (pg. xvii) of Guericke's *New Magdeburg Experiments on the Vacuum of Space*, are testimony to this new experimental-based reality:

> "A thousand Demosthenes, a thousand Aristotles can be laid prostrate by a single man of mediocre talent who has seized upon a better way to find the **truth**. Such a hope, therefore, must be removed: for indeed, men, more learned and superior to us in book-learning, will be found who, to the same of nature itself, can make that which is, in fact, false, true."
>
> — Galileo (c.1635), *Dialogues on the Cosmos* (pg. 35)

> "Theories which are demonstrated by experiment and visual perception must be preferred to those derived from reasoning, however probable and plausible, for many things seem true in speculation and discussion, which in actual fact defy reality."
>
> — Otto Guericke (1672), *New Magdeburg Experiments on the Vacuum of Space* (pg. xvii)

> "It follows from this that all science is empty, deceptive, and pointless unless it is supported by experiment. What inconsistencies otherwise successful and perceptive scholars bring forth without its help! It is experimentation that dissolves all doubts, reconciles difficulties, is a unique teacher of the truth, furnishes a torch in darkness and instructs us how to determine the true causes of things by disentangling knotty problems."
>
> — Athanasius (1631), *Magnetic Art* (pg. 570)

In 1647, Guericke, in the context of this ingrained discerning curiosity, took a typical German fire extinguisher or water squirt gun, called 'Messingen Feuersprutz', or brass fire spray gun, and reconfigured it into a suction device, aka 'vacuum pump', and with this newly-invented device, attempted to withdraw the water from a fully water-filled wooden barrel, shown below right, so to, in effect, experimentally produce a vacuum, inside of the water-evacuated barrel:



Galileo Vacuum Device
(1638)

Guericke Water Barrel Vacuum Experiment
(1647)

Above left, by comparison, we see the wooden piston and cylinder, vacuum measuring device, filled with water, thought up by Galileo (1632), and published in print form (1638), with which one is supposed to pull down on the handle K, by increments of weight, so to see how much force is required to 'break' the vacuum, as Galileo conceptualized things.

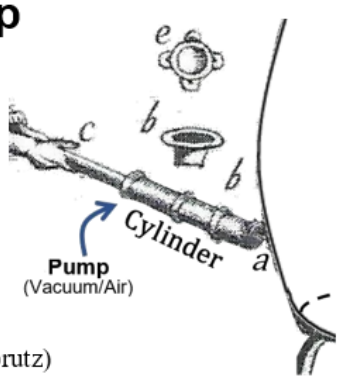
The overlapping similarity, of these two experiments is striking. They both are water filled. Both are wooden systems. Both are experiments aiming to either 'measure' or 'make' a vacuum. Both involve pulling a handle, with great force, in order to affect the vacuum. The former Italian device, is dated nine-years before the latter German device. Here, conjecturally, either this could be what Thomas Kuhn calls 'paradigm change', in respect to independent discovery, or Guericke was inspired by Galileo's device, in the construction of his own device?

We will leave this question open, as it has been debated back and forth, for over a century.[3] It will be presumed, however, that experiments of this kind were 'in the air', similar to how the invention of the telescope, was 'in the air', for nearly a century, e.g. da Vinci (c.1500) to Porta (1589), prior to one actually being built and patented, with intention to sell, via the initiatives of Hans Lippershey (1608).[6] Whatever the case, the following is Guericke's singularly-invented vacuum pump, a device that would change the face of science, over the next four centuries:

Guericke Vacuum Pump
[1647]

Brass Fire Spray Gun
(Messingen Feuersprutz)

Vacuum Pump
(Reverse Messingen Feuersprutz)



The following, in his own words, explains from where this vacuum pump invention and beer keg fluid evacuation experiment came from:

> "When I came to consider the immensity of space and the necessity of its presence everywhere, the **above experiment** came to mind."
>
> — Otto Guericke (1672), *New Magdeburg Experiments on the Vacuum of Space* (pg. #)

In this so-categorized '**first Guericke vacuum experiment**' (as he had many), we see a keg, previously used to store wine or beer, filled to maximal volume with water. Attached to the bunghole or aperture of the

keg, is affixed, a suction, as shown above (with parts a, b, c), or 'Messingen Feuersprutz' (brass fire spray), as was called in his day, a common device used for putting out fires, which he adapted or modified so that it could admit and discharge water, connected via a four-lugged iron ring *e*. The rod *f* or *c* and piston head *g* of the suction pump device is shown to the right of the barrel. This device, as he says, was carefully tooled so that no air or light could enter or leave around the sides of the cylinder. It was also fitted with two leather flaps or valves: one, *a* or d, inside the cover of the pump, adapted for 'admitting' water, the other, *b*, being external, used for 'discharging' water.

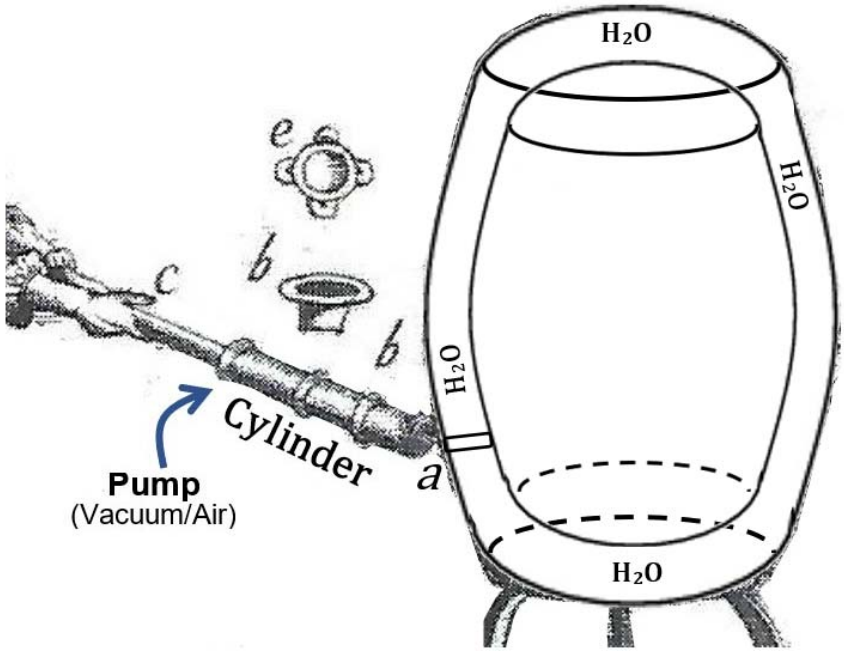
Guericke, independence questions aside, in performing this experiment, had strong insatiable desire to make a 'vacuum', as we have cited above, so to disprove, conclusively, Aristotelian cosmology, regarding space and matter. The following quote captured Guericke's mindset, for some years:

> "All the natural philosophers form Thales to Plato **rejected a vacuum**. Empedocles says that there is nothing of a vacuity in nature, nor anything superabundant. Leucippus, Democritus, Demetrius, Metrodorus, and Epicurus say that the atoms are in number infinite; and that a vacuum is infinite in magnitude. The stoics say that within the compass of the world there is no vacuum, but beyond it the vacuum is infinite. Aristotle says that the vacuum beyond the world is so great that the heaven has liberty to breath into it, for the heaven is fiery."
>
> — Pseudo Plutarch (c.150AD), *The Opinions of the Philosophers* (§1.18: Of a Vacuum); cited by Guericke (1663) in *The New Magdeburg Vacuum Experiments* (§: Empty Space)

Of note, in the first experimental attempt to make a vacuum, the connection between the pump and the barrel broke, before they could get all of the water out of the keg.

In his second attempt, after using stronger connection screws, Guericke found that it took **three hardy men**, pulling on the piston of the pump, to get the water evacuated from the keg, through the upper valve b. At the point when all the water had been evacuated, Guericke recorded that a noise was heard throughout the keg like that of vigorously boiling water, which continued until the keg was *filled with air*, which replaced the water that had been drawn out, indicating, therefore, that air had passed though the wood.

In his so-categorized '**second Guericke vacuum experiment**', in an attempt to remedy this air leaking through the wood problem, Guericke made a 'barrel within a barrel' design, wherein he put a small barrel, filled with water, inside of a larger barrel, which he filled with water, designed so that the suction pump connected to the smaller barrel, through an aperture in the outer barrel, but in a way that it was sealed and air tight at both barrel bungholes, as shown below:



Guericke then had his assistants suck the water out of the small inside barrel, after which, as he claimed, he had made a 'void', which undoubtedly remained. At the end of the day, however, when all the work was finished and all the 'murmuring and roaring had ceased', as he says, there remained a different sound, roaring intermittently, like the soft twittering of a song-bird, which continued for almost three whole day.

Guericke then opened the bunghole of the smaller keg, at which point air rushed in, meaning a partial vacuum, accordingly, had existed for three days; he also found, however, the keg to be partially filled with water, meaning he still had 'sealing' issues. Guericke then repeated this same experiment a number of times, eventually concluding that the porosity of the wood was hindering the achievement of a complete vacuum.

To remedy this issue, in his so-classified '**third Guericke vacuum experiment**', having realized that he needed find a more air-tight variant of a wooden keg, built a new container, shown below, figure II, with a 60 to 70 Magdeburg quart sized copper globe, sealed at the seam with some kind of grease mixture, to which he fitted a stop-cock B, or air-release valve, at the top, and attached the suction pump to the bottom:

With this air-tight setup, using the same methods as before, he sealed the globe, by closing valve B, leaving only air in the globe, and had two strong men attempt to suck all the 'air' out of the globe. At first, as he reports, it was easy to move the piston, but gradually this action became more and more difficult, until they were barely able to draw the rod out. Eventually, the two men began to feel confident that they had essentially extracted all the air. At this point, however, suddenly, to the terror of all, with a loud report or sound, the copper globe collapsed like a cloth crushed in one's hand or as if the globe had been hurled from a tall tower and had crashed with great force into a pancake.

This, to note, was one of the first historical demonstrations, of the immense weight of the atmosphere pressing down onto the surface of the earth. Guericke summarized this as follows:

> "The weight of air on the earth's surface is as great as the weight of water about 20 Magdeburg cubits deep. In other words, if water should rise 20 cubits above the earth surface, the pressure it would exert on all things beneath is the same as the pressure of the air."
>
> — Otto Guericke (1672), *The New Magdeburg Experiments on the Vacuum* (pg. 113)

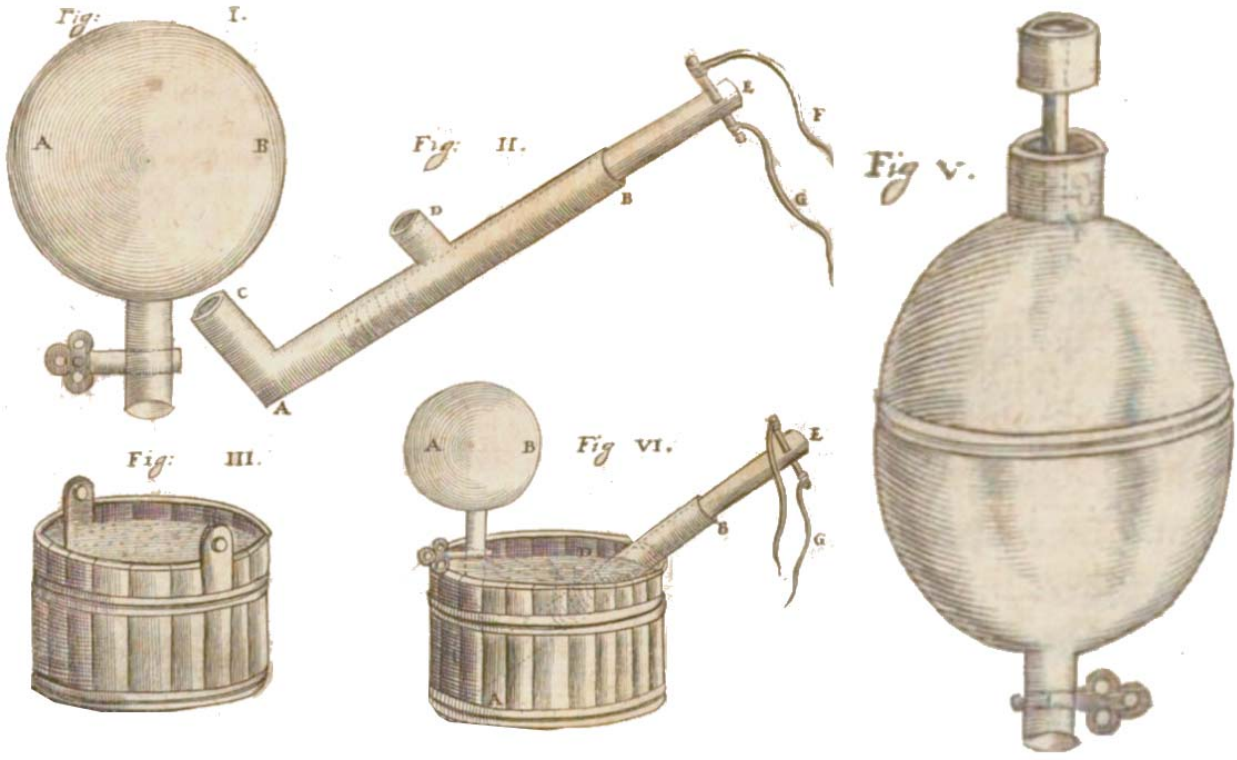
Guericke attributed this result to a flawed design in the spheres, reasoning that if the spheres were perfect, then their parts would equally support each other, and no crushing action would result. Thus, he had is craftsman make a perfect sphere copper globe. This remedy fixed the issue. He repeated the procedure, the sphere held, and he concluded: 'thus a vacuum was produced for a second time'!

Afterwards, when the stopcock B was opened, he reported that air rushed into the copper globe with such force that a man standing in front seemed to be 'drawn to it', and, moreover, that if he moved his face sufficiently close, his breath was taken away. Keep this quote in mind when we get to his 1654 confrontation with the 'Prince of Auerberg', discussed below.

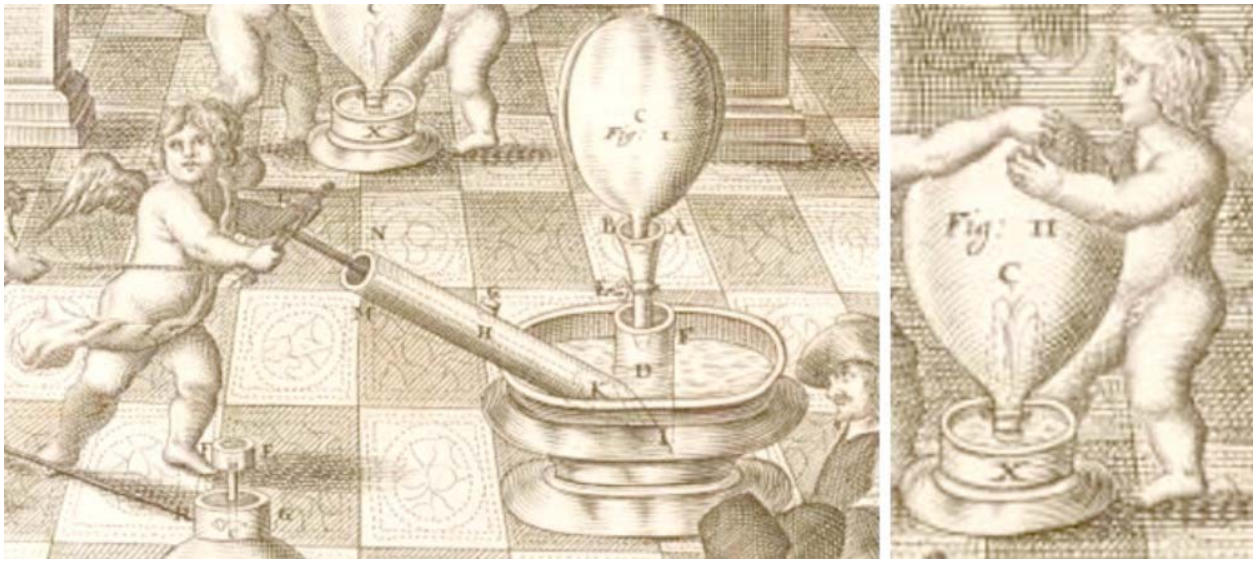
Guericke also noted that a person could not extend his hand over the stopcock without risk of being violently drawn to it. Guericke, in this design, noted that after a day or two, air was found to have leaked into the sphere around the sides of the pump's piston, as well as through the valve and stopcock.

13.1 | Second Generation Vacuum Pump

In c.1653-54, Guericke had made an 'improved vacuum pump', as shown below, which he was demonstrating to people, e.g. at the 1654 Imperial Assembly held at Regensburg:



The following, from the Gaspar Schott (1658) review of this device, shows a putto pumping the above device, which is submerged in a tub of water, water employed to effect sealing solution, so to make a vacuum in the glass globe in the top:

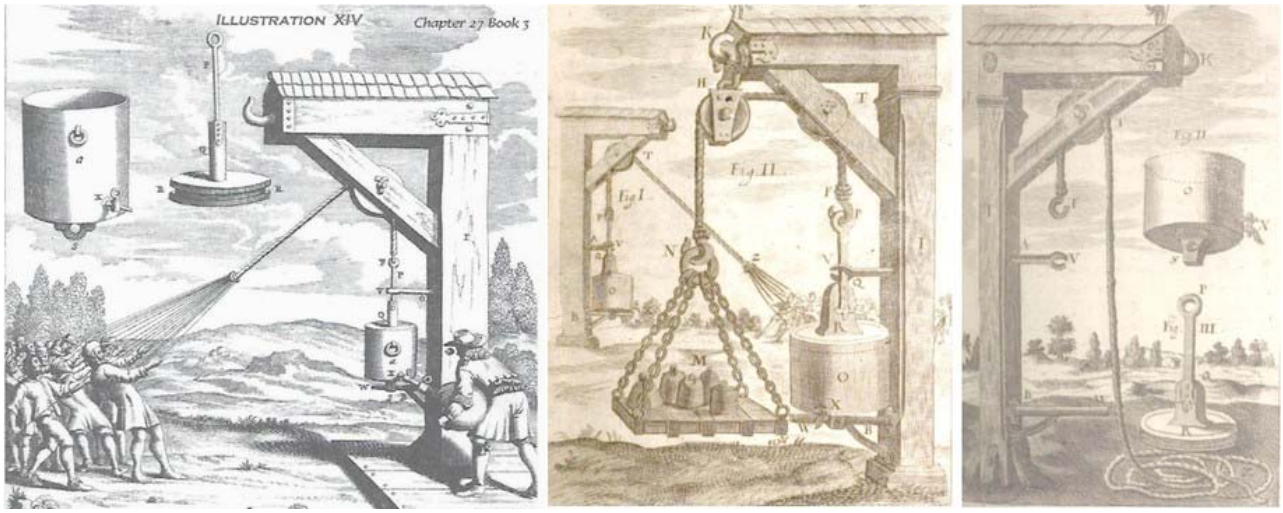


Now, at some point, during the famed 1654 Imperial Diet convention at Regensburg, Guericke commented the following to the 'Prince of Auerberg', Auerberg being then a small province in Bavaria, Germany:

> "In regard to these [vacuum] experiments, if a man should breath into the aforementioned receiver [bulb C, shown above], he would **breath out his life** at the same time."
>
> — Otto Guericke (1654), 'Comment to Prince of Auerberg', Imperial Diet convention, Regensburg; cited by Guericke (1672) in *The New Magdeburg Experiments on the Vacuum* (pg. 169)

Guericke, goes on to state, that the good Prince, 'could not be persuaded to accept my oral account, until he had seen with his own eyes, what had taken place in the glass receiver'.

In late 1654 to c.1655, Guericke, following the Prince's questioning his vacuum experiments, proceeded, as he says, to 'undertake a certain **new experiment**, to prove and confirm' his theory. The following diagram, a veritable linchpin in the history of thermodynamics, was the result:



Guericke, in order to silence the objections of Prince Auerberg, whoever he was, built the above apparatus, so to evidence, that while no one, obviously, will be willing to risk their 'last breath' to test Guericke's conjecture, about the power of the vacuum, the equivalent conclusion that the vacuum bulb, has not only the power to suck one person's last breath, but the power to yank some 20 to 30 men in the air; in his own words:

> "I proceeded to undertake a certain *new experiment*, to prove and confirm my theory, namely that this glass vessel can pull along more than 20 or 30, nay, if you prefer, 50 or 100 men and, if they do not cease this activity, lay them out on the ground."
>
> — Otto Guericke (1672), *The New Magdeburg Experiments on the Vacuum* (pg. 169)

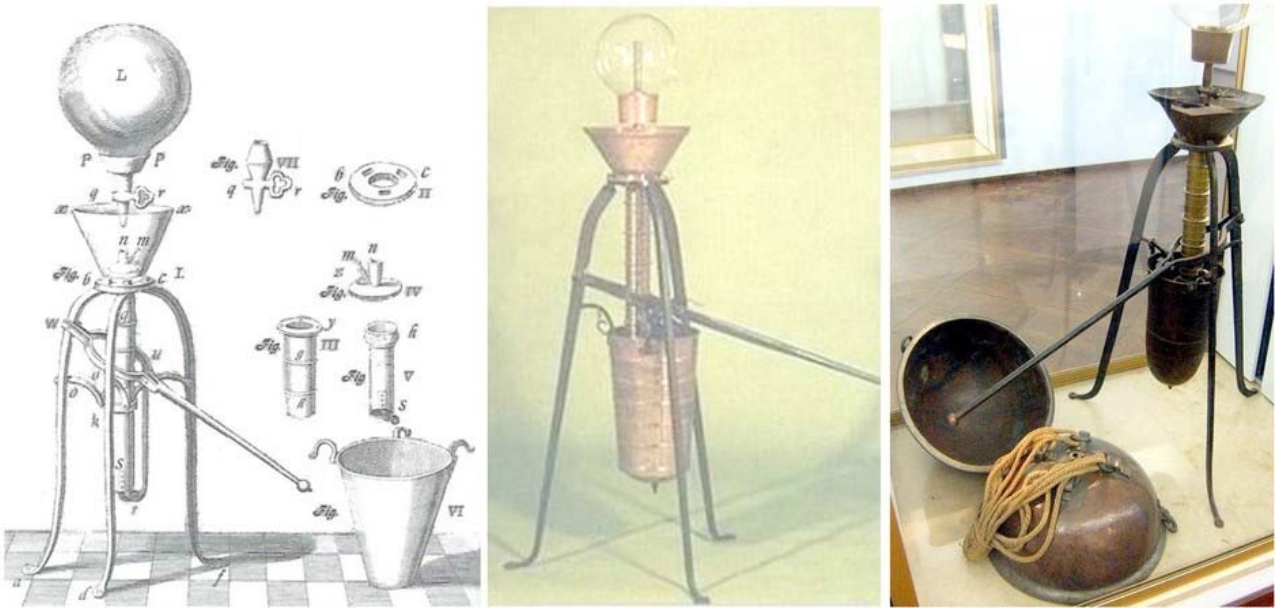
In other words, in order to prove, to Prince Auerberg, that his new vacuum bulb could indeed suck the 'last breath' out of a person, Guericke built the above piston and cylinder vacuum demonstration device, which was able to evidence, before the eyes, how the power of a little vacuum, held in the hands of a boy, above left, is equivalent to the power of 100 men, able to either jerk them forward, or equivalently, able to lift several thousand pounds of weight vertically, as shown above (middle); the engineering model of the now standard 'piston', piston 'rod', and 'cylinder', detailed above (right).

Of note, in respect to the exact dating of this tug-of-war experiment, wherein Guericke takes 'the breath away' of 20 to 30 men, Ditmar Schneider (1986), a noted Guericke historian of sorts, thinks this experiment, which he refers to as 'gas test with piston and cylinder', occurred in c.1659.[8] This late date, however, seems doubtful, being that the entire arraignment was devised just to spoof or rebut the Prince's 1654 laughter. Irritation of this sort would not have taken Guericke five years to remedy; hence we date these 'take one's breath away' and 'gas test with piston and cylinder experiments' to within one year (or at most two years) after the prince's laughter, i.e. 1654-1656, at the latest.

All of this, now-standard thermodynamic logic, was published and disseminated throughout Europe, in the three decades to follow. The veiled history, of how the above pictured so-called Guericke engine (c.1659), transformed into Huygens engine (1673), then the Papin engine (1690), then the Savery engine (1698), then the Newcomen engine (1712), then the Watt engine (1796), to its culmination in the abstract model of the Carnot engine (1824), which we now base the entire operation of the universe on, upon which the increase of the 'equivalence-value of all un-compensated transformations', per heat engine cycle, is based, otherwise known as 'entropy increase', in colloquial dumbspeak, aka the second law of thermodynamics, is based, is like a Russian doll. We can spend much time, reading, and research, attempting to get to the doll within the doll, but, in the end, there are lacking historical details, which block exact understanding. Nevertheless, there are determinate points of historical understanding, as we will discuss.

13.2 | Third Generation Vacuum Pump

In c. 1658 to 1663, Guericke, in upgrade to the pervious suction, built what he called a ‘special apparatus for producing a vacuum’, according to which the vacuum was made via cranking up and down a mechanical arm, as shown below:



Guericke referred to this as his ‘travel model’ vacuum pump. This crank arm model, of note, supposedly, was made *after* Hooke made his rack and pinion vacuum pump, which Guericke became informed about in c.1660. These specifics, however, are but interesting historical details. What matter, is that Guericke showed to the world, via visual demonstration, the ‘power of the vacuum’, actuated in a piston and cylinder, aka a system with a boundary.

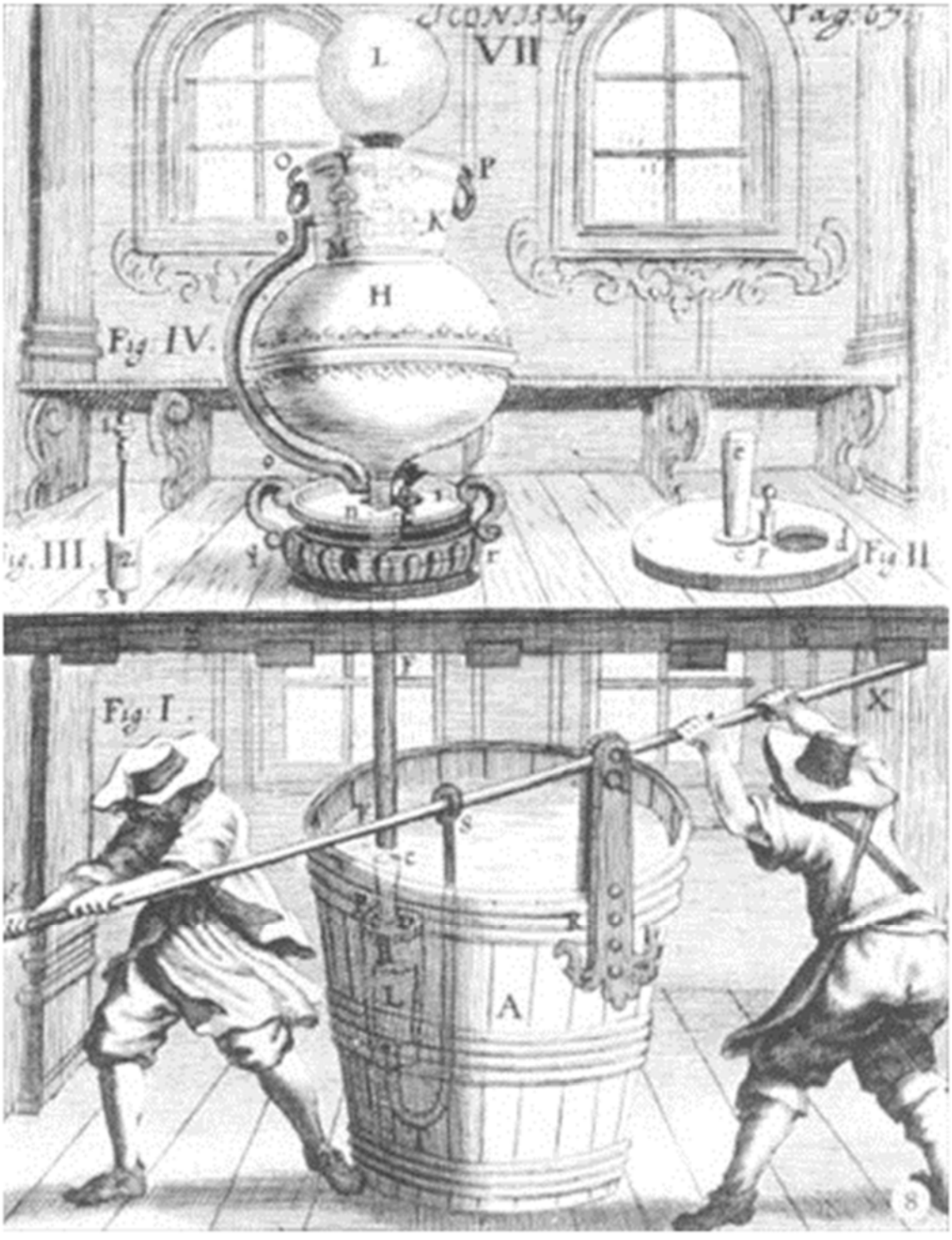
We will but note, in conclusion of this section, that Guericke, made his receiver, or vacuum bulb L, larger, so that he could test larger things inside the vacuum, such as: birds, fish, mice, clocks, bells, candles, along with the preservation of grapes over long periods, to name a few of his experiments done in a vacuum, most of which resonated in history like footnotes in encyclopedias.

13.3 | Fourth Generation Vacuum Pump

In c.1663, Guericke, had begun to have so many visitors come to his home, curious to see what he was doing with his vacuum experiments, that he had to build an audience room, with a large vacuum bulb to display to an audience, on one floor, replete with rows of sitting benches for viewers, and on the floor below, the vacuum bulb was connected to a large vacuum pump operated by two men. A recounting of this is as follows:

> “So many were the visitors that crowded to Guericke's house to witness his marvelous performances, that he had a large pump erected in his cellar, with tubes ascending into an upper room, and connected with suitable apparatus. At great receptions, the pump was driven all day by two men, who kept emptying a very large copper globe of air. When an experiment was to be made, a communication was opened be-tween this globe and the interior of much smaller vessels, the air contained in which was immediately greatly rarefied, and their cavities left nearly vacuous.”
>
> — Charles Weld (1849), ‘A History of the Royal Society: Robert Boyle’

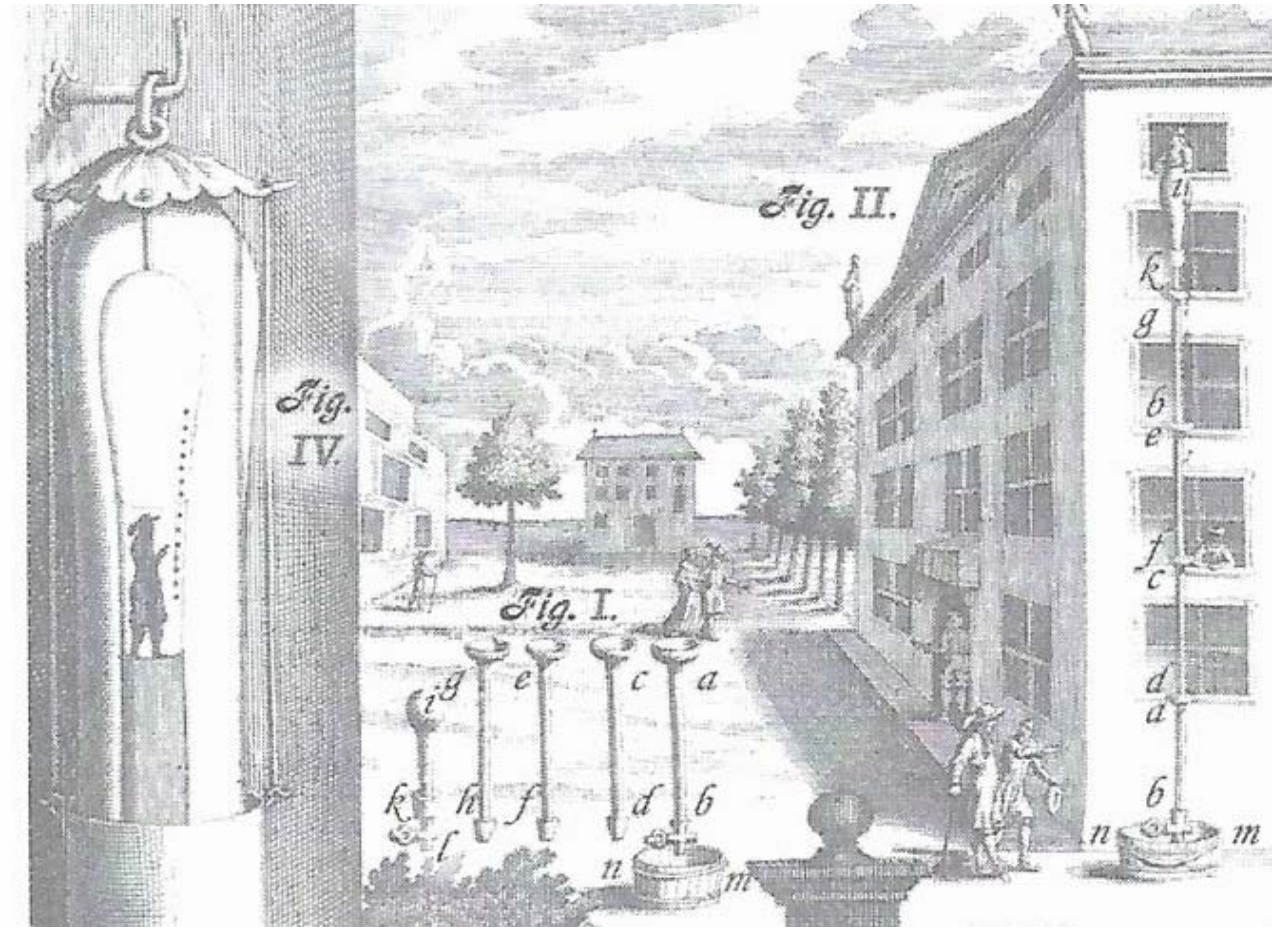
This Guericke ‘fourth generation vacuum pump’, built into two floors, is shown below:



In 1662, Guericke wrote Schott telling him that news of Boyle's book had reached Magdeburg, though Guericke had not yet read it, and so told Schott about plans for a new two-story pump design, according to which the above design would likely have been completed that year.

13.4 | Water Column Barometer

In c.1665, Guericke, did his own water column experiment, as shown attached to his house, similar to what Berti had done previous, but with the addition of a little floating 'wooden man', placed at the top of the column of water, shown next to little marks, so to indicate daily changes in atmospheric pressure:



Had Berti and Magiotti placed marks on their device, and also studied their level L over the course of many days, and noticed variations, it would then technically been classified as the invention of the barometer, a device to measure pressure by increments.

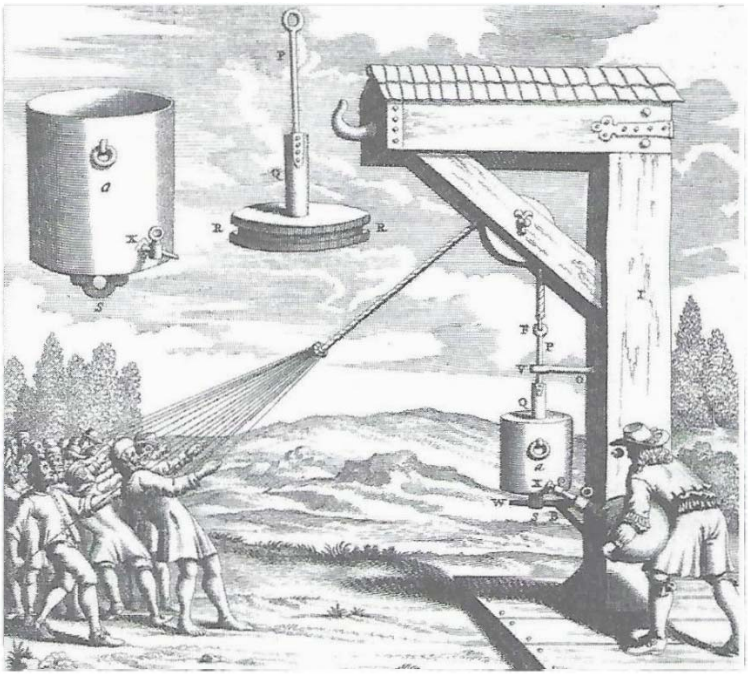
The credit for the invention of the barometer, historically, as generally understood, went to Evangelista Torricelli who, as discussed, repeated the Berti-Magiotti experiment, albeit with the use of mercury instead of water, so to thereby make a smaller version of the device. Guericke, either being influenced, or independently, did the same experiment, with marked gradation, and used these readings to make future predictions about the weather.

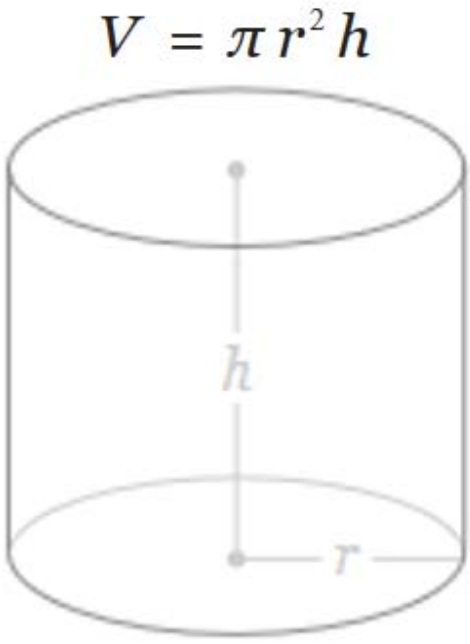
13.5 | Unit of Volume | m^3

The assignment of the origin of the 'unit of volume', in respect to a historical curator of this concept, as far as we are aware, has never been assigned. Here, we will assign this honor to Guericke to the year 1654 when the Prince of Auerberg laughed at Guericke's statement that if a man should place his mouth over an evacuated receiver, he would 'breath out his last breath' at the same time:

> "In regard to these [vacuum] experiments, if a man should breath into the aforementioned receiver [bulb C, shown above], he would **breath out his life** at the same time."
>
> — Otto Guericke (1654), 'Comment to Prince of Auerberg', Imperial Diet convention, Regensburg; cited by Guericke (1672) in *The New Magdeburg Experiments on the Vacuum* (pg. 169)

After which, Guericke devised the following 20-30 man rope pulling demonstration so to appease the laughter of the Prince, wherein a single vacuum bulb or receiver, when attached to a piston and cylinder, with the piston in the raised position, would jerk forward 20 to 30 men, with little effort. This resulting experiment is shown below:





Here, accordingly whenever one attempts to theorize or think about 'volume' in the context of chemical thermodynamics applied to human reactions scenarios, the above visual should come to mind, as a basic model of understanding.

Synopsis: (add)

References

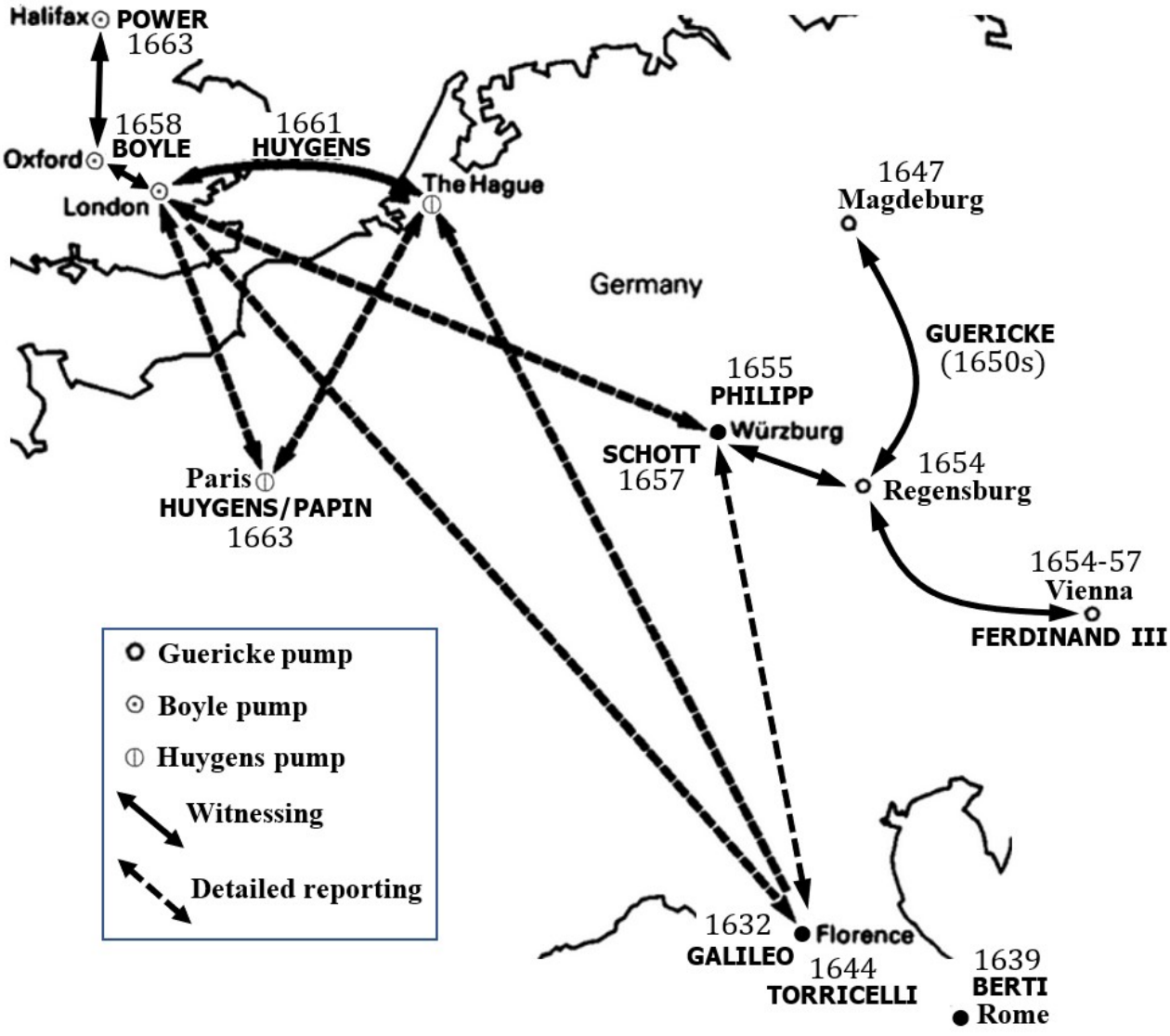
1. (a) Krafft, Fritz. (1978). Otto von Guericke (date "1647", pgs. 55-57; refute Descartes, pgs. 29, 51-55). Darmstadt: Wissenschaftliche Buchgesellschaft.
(b) Helden, Anne. (1991). "The Age of the Air-Pump" (date "1647", pg. 151), *Tractrix: Yearbook for the History of Science, Medicine, Technology, and Mathematics*, 3:149-72.
(c) Conlon, Thomas. (2011). *Thinking About Nothing: Otto von Guericke and the Magdeburg Experiments on the Vacuum* (date "1647", pg. 43). Saint Austin Press/LuLu.
2. http://www.eoht.info/page/Beer+keg+vacuum+experiment
3. http://www.eoht.info/page/Otto%20Guericke
4. http://www.eoht.info/page/Hans+Schimank
5. Guericke, Otto. (1663). *New Magdeburg Experiments: on the Vacuum of Space* (*Ottonis de Guericke Experimenta Nova (ut vocantur) Magdeburgica de Vacuo Spatio*) (translator and preface: Margaret Ames) (Copernican model, pg. 13; Guericke model, pg. 38). Publisher, 1672; Kluwer, 1994; Springer, 2012.
6. http://www.eoht.info/page/telescope
7. (a) Helden, Anne. (1991). "The Age of the Air-Pump" (pdf) (Papin vacuum pump, pg. 164), *Tractrix: Yearbook for the History of Science, Medicine, Technology, and Mathematics*, 3:149-72.
(b) http://www.eoht.info/page/Anne+Helden
8. http://www.eoht.info/page/Ditmar+Schneider
9.

14. Boyle's *Spring of the Air* (1659)

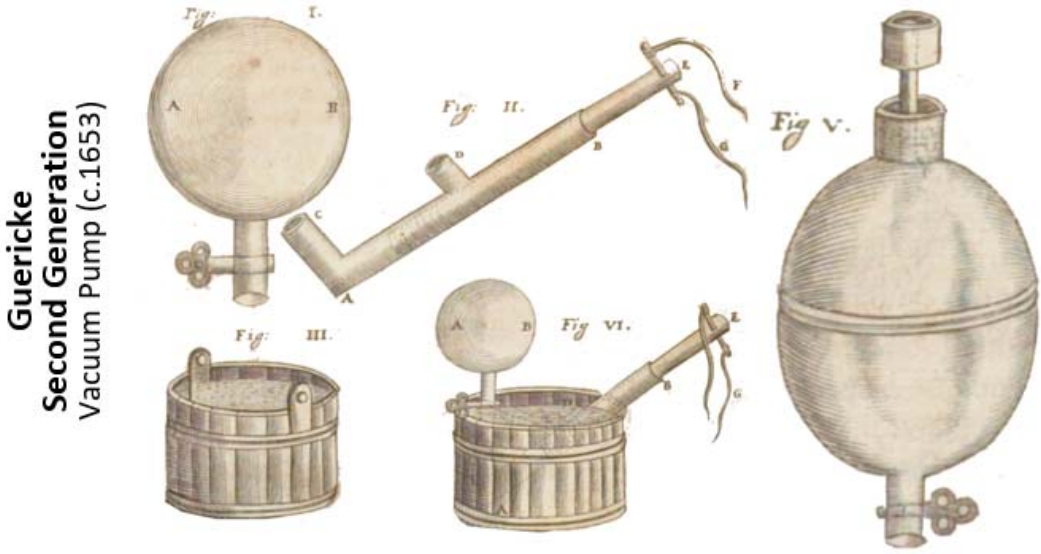
> "The information of sense assisted and highlighted by 'instruments' are usually preferable to those of sense alone."
>
> — Robert Boyle (c.1675), 'Propositions on Sense, Reason, and Authority'

Chapter point: (add) [length: 12-pgs]

In 1657, Gaspar Schott, a German mathematical physicist, residing in Wurzburg, Germany, whose name we saw on the previous air pump development timeline map, in his *Pneumatico-Mechanical Hydraulics,* originally published in Latin, dedicated a 47-page appendix section, entitled 'New Magdeburg Experiments', to Otto Guericke's vacuum experiments, with a few illustrations. News of the appendix, describing the 'German vacuum engine', began to spread into England as follows:[1]



The version described in Schott's appendix was Guericke's 'second generation' vacuum pump, as shown below, with the vacuum-making device submersed in water, to make the seals airtight, along with Guericke's second-generation vacuum pump, with its two openings, through one of them the air is introduced, and through the other it is expelled:



The first to be intellectually awoken by news of Guericke's vacuum experiments was Robert Boyle, a wealth English physicist, chemist, and natural philosopher, residing in London. Boyle, from some years prior, at least since 1655 or before, had encountered reports from the so-called Marin Mersenne 'communication network', which included Evangelista Torricelli, Pierre Gassendi, Gilles Roberval, and others, who had been doing vacuum testing experiments by putting things, like animals, bells, fish bladders, inside of large Torricelli vacuum tubes, including a vacuum-in-vacuum experiment. Boyle, hearing about these Italian and French vacuum experiments, had attempted Torricelli and or Berti like vacuum tests of his own, but with limited success.

In late 1657, Boyle was already so-excited by news of Guericke's vacuum work, that in letters of communication he had conceptualized Guericke's vacuum pump to be of no ordinary beauty:

> "You speak still of the 'German vacuum' as of no ordinary beauty; but Virgil says '*uritque videndo fœmina*'."
>
> — Samuel Hartlib (1658), 'Letter to Robert Boyle', Jan 7

At this point, we note that Boyle did not actually have a copy of Schott's book, but only heard various descriptions of it and its operation; Boyle recounts this, in a letter to his nephew, as follows:

> "You may be pleased to remember, that a while before our separation in England, I told you of a 'book' [*Mechanics of Gas Hydraulics*, 1657], that I had heard of, but not perused, published by the industrious Jesuit Schottus; wherein, it was said, he related how that ingenious gentleman, Otto Guericke, consul of Magdeburg, had lately practiced in Germany **a way of emptying glass vessels, by sucking, out the air at the mouth of the vessel, plunged under water**. And you may also perhaps remember, that I expressed myself much delighted with this experiment, since thereby the great force of the external air, either ruining in at the opened orifice of the emptied vessel, or violently forcing up the water into it, was rendered more obvious and conspicuous than in any experiment that I had formerly seen. And though it may appear by some of those writings I sometimes showed you, that **I had been solicitous to try things upon the same ground**; yet in regard this gentleman was *beforehand* with me in producing such considerable effects by means of the exsuction of air, I think myself obliged to acknowledge the assistance and encouragement the report of his performances hath afforded me."
>
> — Robert Boyle (1659), 'Letter to nephew, Lord Dungarvan', Dec 20

Subsequently, Boyle, in 1658, greatly piqued by news of Guericke's 'way of emptying glass vessels', which he was referring to at this time as a 'German engine', without, at this point, supposedly, having read Schott's appendix summary, decided that he was going to make a 'vacuum pump + air pump' combined device.

The so-called 'practical disadvantages' of Guericke's second generation design, in Boyle's mind, based on the reports he had heard, were firstly it needed to be immersed in a large tub of water, second that it was a solid vessel, such that experimental apparatuses could not be inserted into the vacuum bulb, which is

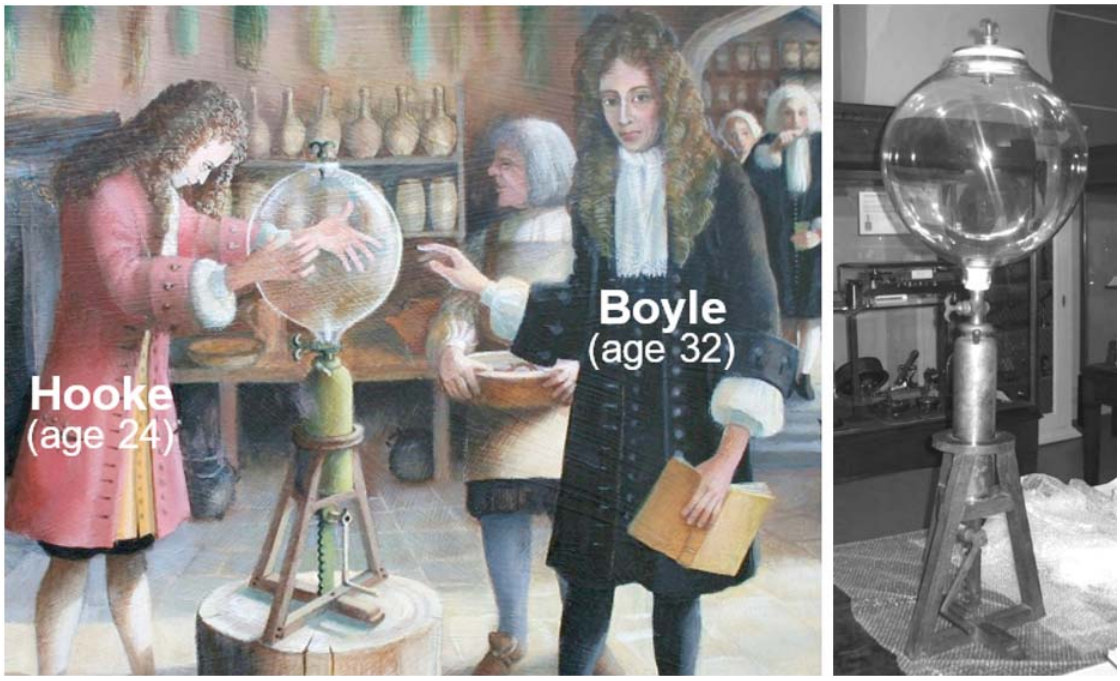
something Boyle had tried to do with a specially-made glove sometime prior, and third it was extremely difficult to operate, requiring the continual labor of two strong men for several hours to evacuate the bulb.[1]

Hence, in 1648, Boyle, powered by his considerable financial wealth, contacted Ralph Greatorex, a London instrument maker, who was then reputed to be the leading pumping engineer in England, and known to have made a considerable sum for draining the Fens, a marshy coastal plain in eastern England. Greatorex, resultantly, built some sort of prototype device for Boyle, but it was not serviceable or did not work, or something to this effect.

Boyle then assigned Robert Hooke, a then 23-year-old, who for the last year had been working as his assistant, to build him an improved Guericke air pump. Hooke, with this new task in hand, went to visit Greatorex, to see what sort of progress he had made, reporting back that 'it was too gross to perform any great matter.' Hooke than went to London to get barrel and some other parts he could not get made in Oxford. By the end of 1658 or early 1659, Hooke had built Boyle an improved air pump. Hooke reflected on his completion of Boyle's air pump, retrospectively, as follows:

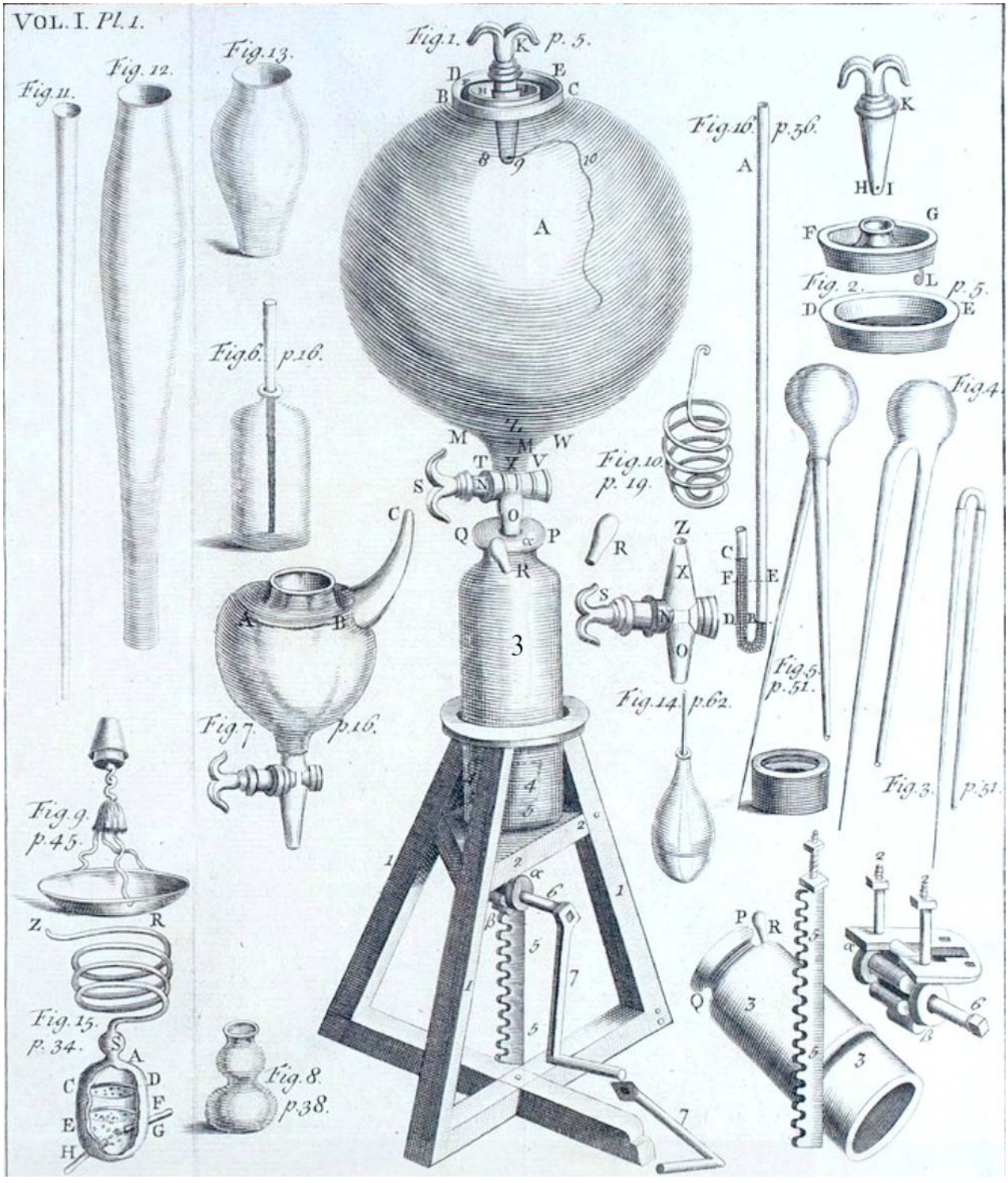
> "In **1658 or 1659, I contrived and perfected the 'air-pump' for Boyle**, having first seen a contrivance for that purpose made for Boyle by Gratorix [Greatorex], which was too gross to perform any great matter."
>
> — Robert Hooke (c.1670), *Posthumous Works* (pg. iii-iv)

The machine that Hooke resultantly built for Boyle is shown below; left being a reconstructive sketch of Hooke and Boyle, right being a reconstructed Boyle vacuum pump:



Hooke referred to this machine as an 'air-pump', Boyle called it 'pneumatical engine', other names include: Boyle's air pump (or Boyle's first air pump), machine Boyleana, rarefying engine, vacuum machine, and Boyle-Hooke air pump, Boyle's vacuum pump, among others. An annotated diagram of this vacuum pump is shown below, along with various experimental accessories.

This device consisted of had a large glass bulb A, that was about 30 quarts (8 gallons or 28 liters) in volume. The glass bulb itself was called a 'receiver', by the glassmakers. At the top of the receiver, was an aperture BC of about 4 inches diameter, that could be opened to allow experimental things inside, e.g. candles, bells, pendulum, barometers (mercury and water), animals such as birds, fish, mice, etc., to test classical doctrines about what can and cannot occur in a vacuum.[2] This 4-inch top opening idea, to note, was Boyle's per reason that several years back he had attempted some type of vacuum experiment, likely an inverted mercury or water column of some design, where he said that he had to use a special glove, with a hole in it, to put things in this earlier vacuum experiment. Hence, this new 4-inch design, allows, as he says in is letter to his nephew, for a man's arm to be inserted, to place or configure different experimental devices.[3]



Fitted into this 4-inch aperture, was air-tight stopcock pin K, which as shown separately, below top at right, has a small hole HI in it through which a string 8,9,10 fitted, which allows for the experimenter to move or pull things inside the vacuum, e.g. ring the bell or do his 'separation of two plane surfaces' experiment, in vacuo. For experimental devices that were longer than the size of the receiver, such as the device of figure 16, specially-made sealed fittings were made to fit into section opening BC.

The bottom of the receiver narrowed to fit into a brass fitting device N that contained a stopcock S, kind of the connecter between the receiver and the cylinder. This, in turn, was fitted, at point O, into the top of a brass cylinder 3, at opening QP. At the lip or top of the cylinder is valve R, that when turned will either let air out, or let air in.

Inside the cylinder is a wooden piston, or 'sucker' as they called it, wrapped in 'tanned shoe leather', which is shown in the dotted line location 4. The piston was worked up and down by a rack-and-pinion system, made of rack 5 and pinion 7. The entire machine rested on frame I. The top part, in sum, is called the 'receiver'; the bottom part called the 'air pump', at first, then later a 'sucking pump'. To make the entire machine air-tight, the poured salad oil into the bottom of the receiver, into the cylinder and piston area, and around the various valves.

To operate this vacuum making machine, i.e. to remove or evacuate air from the receiver, firstly the piston is cranked up to the top position, so that no 'space' or air remains in the cylinder and piston. Next the receiver is inserted into the cylinder at the neck portion O, into mouth QP. The stopcock or plug R closed and the stopcock S is opened. The piston is then cranked down to the bottom position, which works to pull some of the air out of the receiver. When the piston gets to the bottom position, the stopcock S is closed, thus sealing off the receiver. Next the plug R is removed or turned, which thus allows the now partially evacuated air, contained in the cylinder, to connect with the air of the atmosphere. The piston is then cranked up to the top position, and the process is repeated. Boyle explains this operation process as follows:

> "All things being thus fitted, and the lower shank O of the stopcock being put into the upper orifice of the cylinder, and into which it was exactly ground; the experimenter is first, by turning the handle, to force the sucker to the top of the cylinder, that there may be no air left in the upper part of it. Then, shutting the valve with the plug, and turning the other way, he is to draw down the sucker to the bottom of the cylinder; by which motion of the sucker, the air that was formerly in the cylinder being thrust out, and none being permitted to succeed in its room, it is manifest, that **the cavity of the cylinder must be empty in reference to the air**. So that if thereupon the key of the stopcock be so turned, as that through the perforation of it a free passage be opened betwixt the cylinder and the receiver, part of the air formerly contained in the receiver will nimbly descend into the cylinder. And this air being, by the turning back of the key, hindered from the returning into the receiver, may, by the opening of the valve and forcing up of the sucker to the top of the cylinder again, be driven out into the open air. And thus buy the repetition of the motion of the sucker upward and downward, and by opportunely turning the key, and stopping the valve, as occasion requires, more or less air may be sucked out of the receiver, according to the exigency of the experiment, and the intention of him that makes it."
>
> — Robert Boyle (1659), 'Letter to nephew, Lord Dungarvan', Dec 20

Each 'exsuction', as Boyle referred to it, required progressively more force as the amount of air remaining in the receiver became more and more rarefied and diminished, wherein, during each *exsuction*, magnitude of the vacuum increased, inside the receiver bulb. This was in fact the finding of is very first experiment, which he recounts, notice the peculiar way he explains things, as follows:

> "And, therefore, upon shutting the receiver by returning the key, if you open the valve, and force up the sucker again, you will find, that after this first *exsuction* you will drive out almost a whole cylinder full of air: but at the following exsuctions, you will draw less and less of air out of the receiver itself; and consequently, the particles of the remaining air, having more room to 'extend themselves' in, will less press out one another."
>
> — Robert Boyle (1659), 'Letter to nephew, Lord Dungarvan' (pg. 8), Dec 20

Boyle then explains how, in this first experiment, he was able to 'gauge' the level of the vacuum, following a series of *exsuctions*, by the point reached when the atmospheric pressure had the ability, on its own, to spin the rack-and-pinion handle, and raise up the piston:

> "This you will easily perceive, by finding, that you still force less and less air out of the cylinder; so that when the receiver is almost exhausted, you may force up the sucker almost to the top of the cylinder, before you will need to unstop the valve to let out any air. An if at such time, the valve being shut, you let go the handle of the pump, **you will find the sucker forcibly carried up** to the top of the cylinder, by the protrusion of the external air; which, being mush less rarified than that within the cylinder, must have a more forcible pressure upon the sucker, than the internal is able to resist: and by this means you may know how far you have emptied the receiver."
>
> — Robert Boyle (1659), 'Letter to nephew, Lord Dungarvan' (pgs. 7-8), Dec 20

To explain this peculiar finding, Boyle introduces his 'spring of the air', according to which the particles are envisioned to be like little watch springs, that when compressed, like in the weight of the atmosphere, are

forced together, but when allowed into evacuated spaces, move such that their ‘springs’ are allowed to expand, or something along these lines; Boyle explains it thusly:

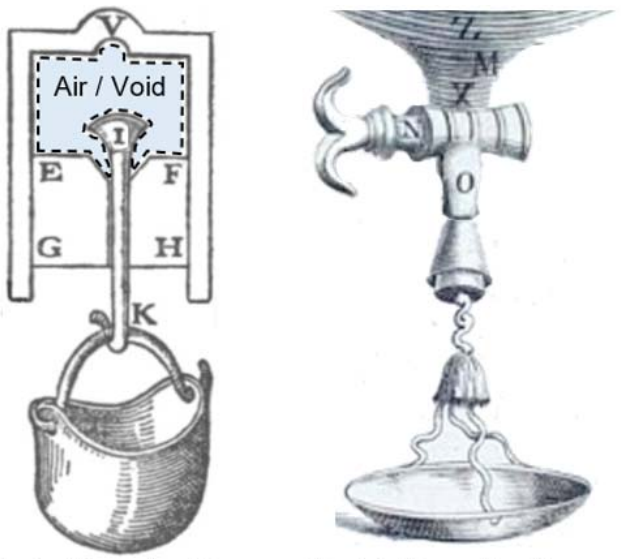
> “There is a **‘spring’ or elastic power in the air we live** in. By which ‘έλατηρ’ or ‘spring of the air’, that which I mean is this: that our air either consists of, or at least, abounds with, parts of such a nature, that in the case they be being or compressed by the weight of the incumbent part of the atmosphere, or by any other, body, the do endeavour, as much as in them lieth, to free themselves from that pressure, by bearing against the contiguous bodies that keep them bent; and, as soon as those bodies are removed, or reduced to give them way, by presently unbending and stretching out themselves, either quite, or so far forth as the contiguous bodies that resist them will permit, and thereby expanding the whole parcel of air, these elastical bodies compose.”
>
> — Robert Boyle (1659), ‘Letter to nephew, Lord Dungarvan’ (pgs. 8), Dec 20

On 20 Dec 1659, Boyle dispatched the first public details of his experiments, such as experiment #1, via a letter, quoted above frequently, to his nephew Lord Dungarvan, which was kind of his ‘public notice’ of what he was doing.

In 1660, Boyle letter was published as *New Experiments: Physico-Mechanical, Touching the Spring of the Air, and its Effects: Made, for the most part, in a New Pneumatical Engine*, wherein he detailed 43 experiments he had performed inside of his vacuum receiver. These include repeats those done previously by the Italian and French physicists, such as the bladder in vacuum experiment (#4), done previously by Gilles Roberval (1648); an expansion of air by heat volume measurement (36), discussed previous by Marian Mersenne; the void-in-void mercury experiment (#17) and void-in-void water experiment (#19), done first by Blaise Pascal, but reported by Jean Pecquet (1651), the sound in vacuum experiment, using a watch instead of a bell, as first suggested by Athanasius Kircher during the Berti vacuum experiments (c.1639); the separation of two plane surfaces (#31), first employed by Lucretius (60BC) as evidence of the existence of a vacuum; an attempt at air weighing, done previous by Guericke (c.1650s); a fly, bee, butterfly (#40), lark, and mouse (#41) in a vacuum; done previously by Roberval (c.1647).

14.1 | Vacuum Lifts a Weight

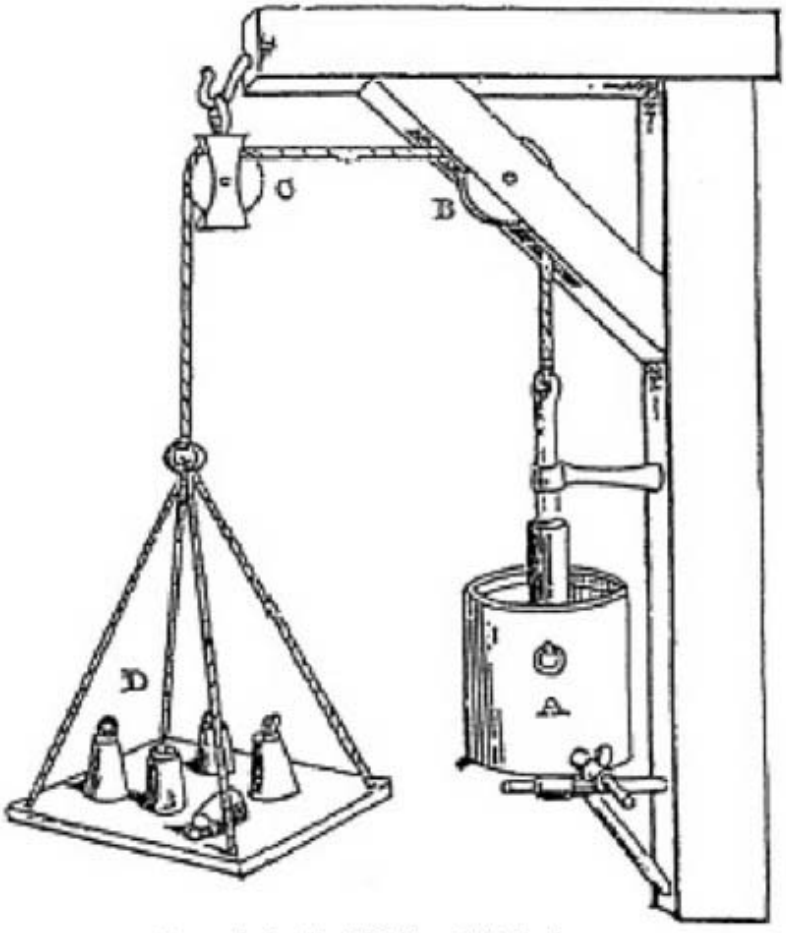
In experiment #32, shown below right, Boyle realized Galileo’s 1632 (published 1638) vacuum measuring thought experiment, shown below left. Specifically, Boyle evacuated the receiver, then sealed it, then attached a specially made stopper to the bottom end of the receiver at section O. The then opened the receiver, therein making a vacuum connect to the stopper, mean the weight of the atmosphere pressed up and around the stopper, and then began to add one ounce weight, incrementally, to the attached tray, to see how much weight it would take to break the vacuum, eventually getting up to 10 pounds of weight in tray:



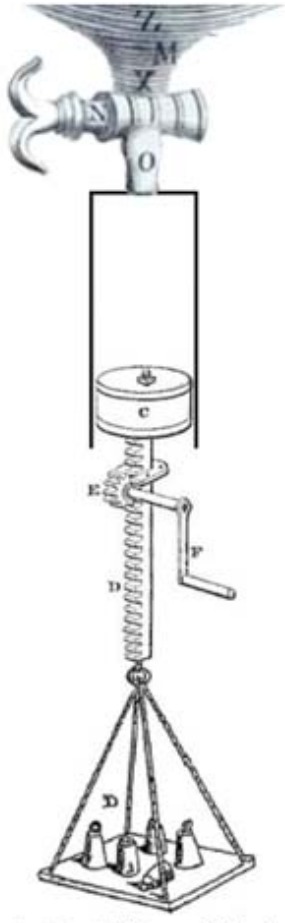
Galileo’s Measuring Vacuum with Weights Experiments (1632)

Boyle’s Measuring Vacuum with Weights Experiments (1659)

In experiment #33, shown below right, Boyle, unknowingly repeated the same experiment performed earlier by Goethe, below left, both of which amounting to attaching an evacuated receiver bulb to a piston, extended back to the open-ended side of the cylinder, to its farthest back position, then, with certain incremental amounts of weight being added to a tray, which attaches to the rod of the piston, the receiver valve is opened, and one tests to see just how much an evacuated receiver can lift:



Guericke's Lifting Weights with Vacuum Experiments
(1655-56)



Boyle's Lifting Weights with Vacuum Experiments
(1659)

Boyle, in his passing experiment, tested up to a lifting capacity of 28 pounds. Guericke, by comparison, being engrossed in these vacuum experiments for more than two decades, managed to get his vacuum bulb to lift up to 2,686 pounds of weight.

Here, to pause, in respect to the 'history of thermodynamics', generally, with particular respect to the invention of the heat engine, secondarily, above we see the pure operational aspects of thermodynamics. It takes us, as intellectually growing CHNOPS+ things, another 215-years of thought to go from the above basically straight-forward diagrams to a standard textbook model explaining the operation of these vacuum engines, as penned in Clausius' 1875 second edition of *Mechanical Theory of Heat*. Moreover, at the present penning of this treatise, we're are pushing 360+ years past the above vacuum engine experiments, and we still do yet even a standing basic treatise on how social vacuums can lift weight or do work?

The 'work' of a man cranking the pump arm of the Guericke pump, or turning the rack-and-pinion arm of the Boyle pump, gets converted into stored potential energy in the receiver bulb, which as Guericke showed is a potential or energy that can be stored for several months. This stored vacuum energy, when needed, e.g. for an experiment in Boyle's case, or a public demonstration in Guericke's case, can then be attached to the valve of raised cylinder engine, and therein employed in the 'work' of lifting a weight through vertical distance in height.

In this case we have, in modern speak, the photosynthetic 'heat' content of plants, which gets converted into the 'energy' of the meat of animals, both of which being consumed by humans, to yield the muscular

'work' of the mechanical operation of the pump arm, which gets transformed into the stored potential 'energy' of the vacuum, which gets converted into the, lifting weight against the force of gravity 'work' energy seen in the raising of the weights, through unit distance.

At this point, all one needs, is to figure out, in a clever way, how to make the vacuum with heat or fire directly, thus circumventing or 'skip' the three energy transformations of solar energy becoming plant tissue, then animal tissue, then human muscular energy, and thus realize a great engine in nature.

The ancient Greeks, from Ctesibius to Hero, as we have touched on, were in the neighbor hood of this principle, and Da Vinci, likewise, clearly had the principle worked out, but like most of his designs never took the idea or prototype to the operation realization stage. Over the course of the next 40-years, following directly from this 1660 *New Experiments* publication of Boyle's, the push of this general 'heat makes vacuum which raises weight' principle, was realized.

It was in fact Boyle's assistant Robert Hooke who first put this weight raising 'principle' to paper, specifically in his 'future invention #9', of his 1675 *Description of Helioscopes and Other Instruments*, wherein he but boasted, in his usually style, that the following encrypted Latin cypher: 'Pondere premit aer vacuum quod ab igne relictum est', contains the secret for a 'New Invention in Mechanics of Prodigious Use, Exceeding the Chimera's of Perpetual Motions for Several Uses', the coded message, the cypher key for which he did not divulge publicly until a decade or two later, reading as follows:

> **"The vacuum left by fire lifts a weight."**
>
> — Robert Hooke (1675), *Description of Helioscopes and Other Instruments* (pg. #)

It would be Christiaan Huygens, as we will discuss shortly, who actually was the first to attempt to tackle with problem, via his gunpowder engine experiments, and to attempt to construct a working realization of this so-called *vacuum left by fire lifts a weight principle*. Moreover, it was Denis Papin, Huygens assistant, who later became assistants to both Boyle and Hooke, that in 1690 pulled all this testing and idea stage logic, into a draft entitled 'A New Method for Obtaining Very Great Motive Powers at Small Cost' for a basic operational heat engine.

Papin's *New Method* was translated into English and published in the Royal Society notes of 1695. This was read by Thomas Savery, as has been logically deduced, based on circumstantial evidence, who in Jul 1698 patented so-called Savery engine, and in 1699 presented a working model to the Royal Society. Savery's engine was then improved upon by Thomas Newcomen, one of Savery's neighbors, who it is said might have had a working Papin-style steam engine model operational before Savery, as some have conjectured, who, of note, had connections to Hooke and Papin, and the rest is simple steam engine history.

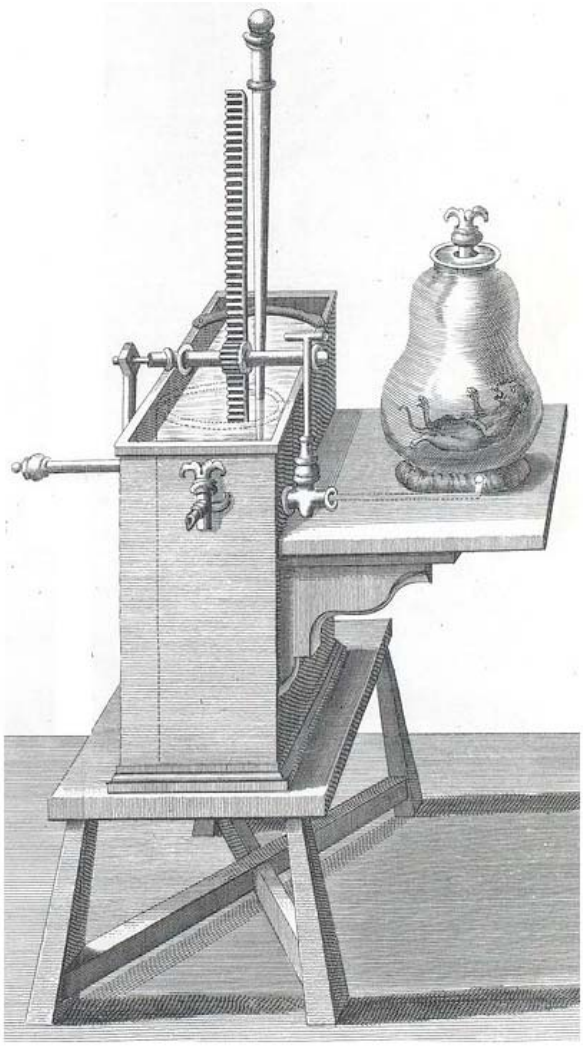
In respect to the soon to be commonplace theological implications of what was actuating here, in these weight raised by vacuum experiments, which amounts to motion reduced to mechanical definition, Henry More, an English philosopher, attempting to reconcile Plato, Christianity, and the new vacuum-proposing mechanical philosophy, in his 1653 *Anecdote Against Atheism*, devoted an entire philosophical section to an attack on Boyle's vacuum work, with focus on experiments #32 and #33; this has been summarized as follows:

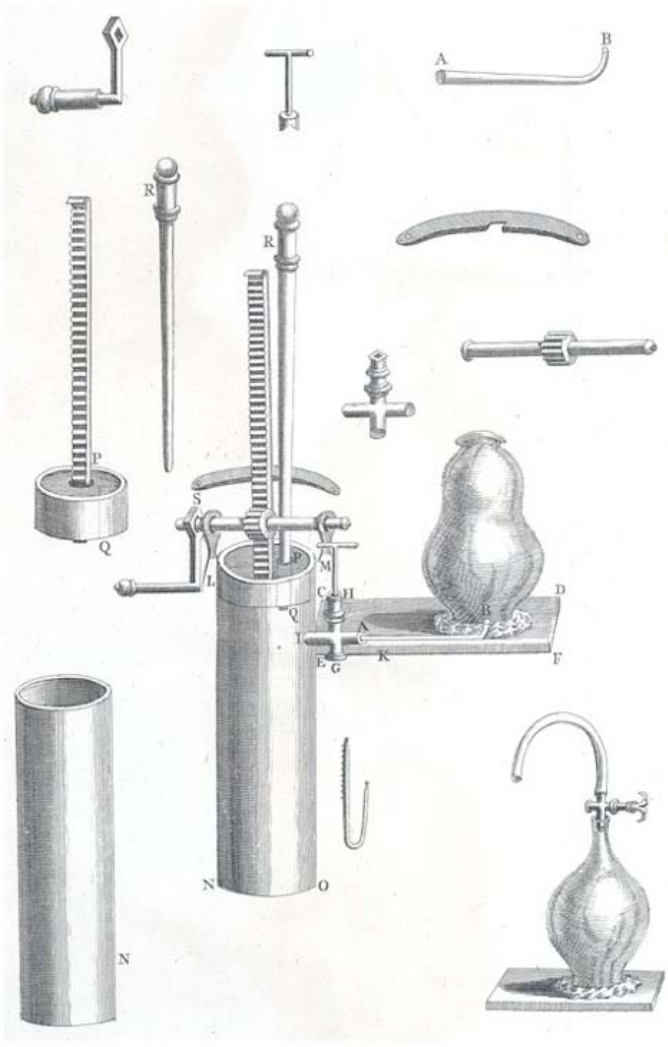
> "More appealed to Boyle's experiments #32 and #33 in which large weights were lifted by the sucker [piston] reascending into the cylinder. More claimed that these trials showed the limited applicability of any mechanical law of gravity, and that there 'is a principle transcending the nature and power of matter that does umpire and rule all."
>
> — Steven Shapin (1985), *Leviathan and the Air Pump* (pg. 212)

(add)

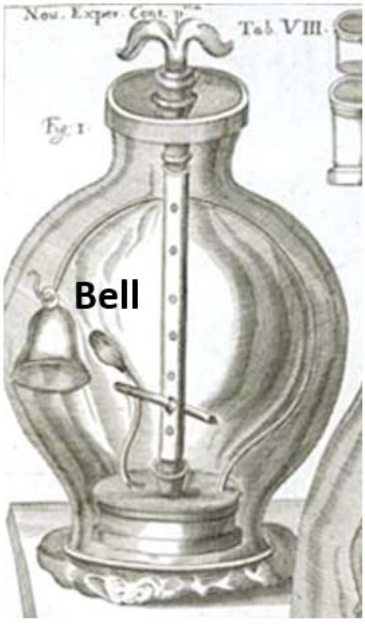
14.2 | Second Generation Vacuum Pump

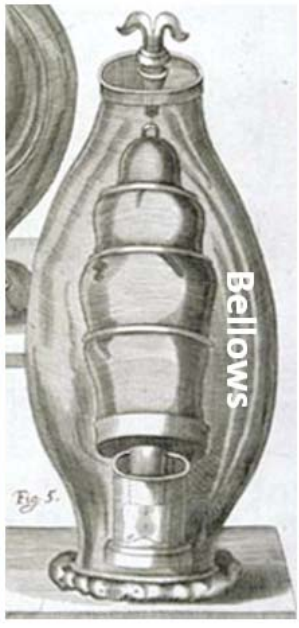
In 1662, Boyle built a second-generation vacuum pump, wherein the piston and cylinder were submerged under water, and the receiver was attached on a side board, and was made such receiver bulbs if different sizes could be used, fit to different types of experiments.





The following are illustrations of some of Boyle's vacuum experiments:





Left, we see his 'bell in vacuum' experiment, to test if sound could be heard. Center left, we see the famous painting of his 'bird in vacuum' experiment, wherein Boyle, later 'froze' a bird inside of a 'vacuum', done to disprove Thomas Hobbes 'wind theory of cold', according to which things can only freeze when wind

blows on them. At right, we see Boyle's 'fish in vacuum' (or originally ell in vacuum as discussed in experiment #41), and 'mouse in vacuum' experiments.

We will also point out that some of these vacuum experiments were conducted over long periods of time, in attempts to ascertain things such as the growth of plants in a vacuum and the 'preservation of animals and other bodies' in a vacuum. Here, we will note that Denis Papin, the person behind Papin engine, the engine model behind the Carnot engine, who we will meet shortly, in 1699 was completing his MD degree doing work on the preservation of foodstuffs in a vacuum.[4] Hence, it would seem plausible that Papin new of Boyle's vacuum work before this.

14.3 | Power-Boyle Law

In 1653, Henry Power, an English physician, along with his associate Robert Towneley, a scientist, whose family Power was the physician for, both having presumably read Jean Pecquet's 1651 *New Anatomical Experiments*, which was translated into English in 1653, and in which all the Italian and French vacuum experiments were summarized, began doing Pascal-themed vacuum mountain climbing experiments.

On 6 May 1653, Power and Towneley carried a Torricelli barometer to the top of Halifax Hill, to a height of 1,000 feet. They also inverted a Torricelli tube with different volumes of air inside to test for air volume change with various tube lengths; as tabulated in the adjacent table.[5]

Liquid in the apparatus	Tube length	Original air volume	Air volume after inversion of the tube
Mercury . .	45	2	4
Mercury . .	45	14	16
Mercury . .	45	40	42
Mercury . .	29	14 1/2	15 1/2
Mercury . .	27	13 1/2	18 1/2
Mercury . .	21	10 1/2	14 1/2
Mercury . .	18	9	10
Water . . .	45	22 1/2	24 1/2

All of these experiments, were generally inconclusive, but digging in the right direction, in respect to attempting to find a quantitative relation between pressure and volume. Over the next seven or so years, Power and Towneley never published anything and went onto different subjects. When, however, Boyle published his *New Experiments* in 1660, they were then again drawn into doing more experimental work.

On 27 Apr 1661, Power and Townley combined the effects of two previous experiments by enclosing a volume of air above mercury and measuring its change at two atmospheric pressures, at the foot and apex of Pendle Hill in Lancashire, which has an elevation of 1,827 feet. They repeated the experiment using a tube of different length, and measured the pressure at each volume with a standard Torricelli tube containing 29 inches of mercury. They then compared the pressure exerted on the enclosed air P1 and its consequent volume V1, with the same measurements at the different pressure P2 and volume V2. They called these four figures 'proportionals', concluding thusly:

> "Here are now four proportionals, and by any three given, you may strike out the fourth, and by conversion, transposition, and division of them. So that by these analogies, you my prognosticate the effect, which follow in all mercurial experiments, and predemonstrate them, by calculation, before the senses give an experimental eviction thereof."
>
> — Henry Power (1663), *Experimental Philosophy* (pg. 130)

Hence, according to Charles Webster (1963), who did his MS degree on Power and Boyle's Law, this yield the following relation:[6]

$$P_1 V_1 = P_2 V_2$$

which yields the following:

$$P_1 = \frac{P_2 V_2}{V_1}$$

Then, supposing or assigning P_2V_2 to be a constant, yields this:

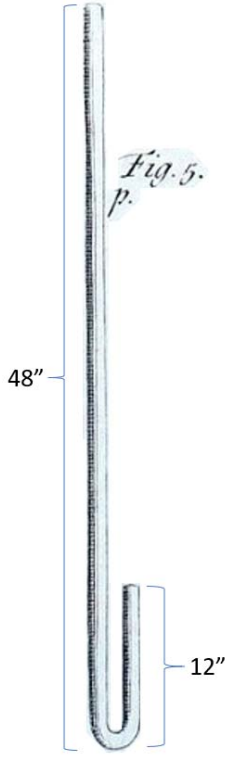
$$P_1 = \frac{K}{V_1}$$

which, without subscripts, the general pressure is inversely proportional to volume equation:

$$P = \frac{K}{V}$$

Power then wrote an 'unsigned' letter to Boyle, about their new pressure-volume experiments, titled 'Additional Experiments made at Townley Hall, in the years 1660 and 1661, by the advice and assistance of that heroic and worthy gentleman Richard Townley, and those ingenious gentleman John Townley, Charles Townley, and George Kemp', about their findings. Power, however, supposedly forgot to add his name to the article, being its author. Boyle, therefore mistakenly came to refer to this new pressure volume inverse relation as Towneley's hypothesis.

In 1662, Boyle, in the second edition of *New Experiments*, Boyle, in chapters 4 and 5 of Part 2 of the appendix, which was concerned with a rebuttal to the objections of Franciscus Linus, a Jesuit Aristotelian scientist who objected to his work on theological grounds, referred to 'Townley's hypothesis' or 'Townley's supposition', which Boyle says is the proposition that 'air loses of is spring by dilation'. Boyle also says that he told Hooke about this, and Hooke responded that he had thought along the same lines, a year ago, saying that he concurred with 'Townley's theory'.



In any event, in the appendix chapter 5: 'Two new Experiments touching the measure of the Force of the Spring of the Air, Compressed and Dilated', Boyle explains how he tested Townley' hypothesis, i.e. Power's hypothesis, correctly speaking, by a J-tube, 48-inches no the long side, 12-inches on the short side, and sealed on the short side, shown adjacent. They then started with the mercury line the same in both tubes, then inch by inch adding in more mercury, to the long tube, and measure the compression in volume of air in the short tube.

The results are shown in the adjacent table, where second A column is the height of the column of air in the short tube, and B is the height of the mercury in the long tube. Column D is there calculated pressure of the air volume, in the short tube, and where column E is, as Boyle famously puts it:

> "What that pressure should be according to the [Power-Townley] hypothesis, that supposes the **pressures and expansions to be in reciprocal proportion**."
>
> — Robert Boyle (1662), *New Experiments* (§A5, point E, pg. 101)

This statement that 'pressure and volume expansions are reciprocal in proportion' is commonly now known as 'Boyle's law', whereas correctly it should be 'Power' law', as Henry Power seems to have been the lead experimenter, who had Richard Townley as his funder, and Townley's family members, John and Charles, along with George Kemp, as experimental assistants. Boyle, at the end of this appendix chapter says the following:

> "Now although we deny not, but that in our table some particulars do not exactly answer to what our formerly mentioned hypothesis might perchance invite the reader to expect; yet the variations are not so considerable, but that they may probably enough be ascribed to some such want of exactness as in such nice experiments is scares avoidable. But for all that, till further trial hath more clearly informed me, I shall not venture to determine, whether or not, the intimated theory will **hold universally** and precisely, either in condensation of air, or rarefaction."
>
> — Robert Boyle (1662), *New Experiments* (§A5, pgs. 101-02)

In any event, here we see Boyle suggesting a possible 'universal law' of pneumatics, which, while not itself universal, i.e. the Power-Boyle law of pressure and volume varying inversely only tends to hold in ideal gas type situations, it is the first quantitative law in universal science of thermodynamics.

In 1686, Isaac Newton, in his *Principia* (book 2, section 5, proposition 23, theorem 18), as summarized by Partington (1937), 'deduced' the Power-Boyle law, by assuming that a gas is composed of particles repelling one another with a force varying inversely as the distance, and using the decrease in volume of a rectangular cube, as a geometrical basis of argument.

In 1893, Walther Nernst, his 1893 *Theoretical Chemistry from the Standpoint of Avogadro's Rule and Thermodynamics*, skipping about 235-years of gas law theory development, we get the modern version of the ideal gas law, as shown below, wherein the product of the pressure P and volume V are equal to the product of the particle count n, ideal gas constant R, and absolute temperature T:

$$PV = nRT$$

The various precursory gas laws themselves, such as Amontons law (1702) or Charles Law (1778), whose names tended to vary per continent, e.g. in France they referred to Boyle's law as 'Mariotte's law', that went into the finalized formation of the ideal gas law, to note, is a long and convoluted historical subject in and of itself. There have been, in fact, more than 60-equations or 'equations of state' suggested to express the complete behavior of a substance over the whole range of measured P, V, and T values, per reason that it is 'impossible', as Mark Zemansky (1979) puts things, to do this with one single equation.[9]

We will touch later on various attempts at social ideal gas laws, but with respect to our subject matter, people are *surface attached molecules*, not gas molecules. To repeat: 'humans are not gas molecules' that move about chaotically with so-called 'uncorrelated velocities'. This important point has been frequently confused and abused, particular in the newly-growing fields of sociophysics or econophysics.

The important point to keep in mind, here, is that all of this vacuum work, undertaken by Boyle, was carried forward by Christiaan Huygens in France, as we will discuss shortly; and that in 1673, Huygens took on a new assistant named Denis Papin; who became Boyle's assistant in 1675 and then Hooke's amanuensis in 1679; all of which worked to stimulate the theoretical Papin engine (1690), which led to the Carnot engine (1824), which led to the Clausius engine (1865), wherein thermodynamics was founded.

Synopsis: (add)

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(b) http://www.eoht.info/page/Steven+Shapin
2. http://www.eoht.info/page/Receiver
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7. Boyle, Robert. (1662). *New Experiments* (Appendix §: A Defense of the Doctrine Touching the Spring and Weight of the Air, chapter V, entitled "Two new experiments touching the measure of the force of the spring of the air compressed and dilated"). Publisher.
8. Partington, James. (1937). *A Short History of Chemistry* (pg. 166). Dover, 1957.
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10.

15. Huygens

> "Huygens, after observing Boyle's air pump, in 1661, then replicated and modified this instrument in Holland in 1662, and then again for the Montmor Academy in Paris in 1663, and finally for the Royal Academy in 1668."
>
> — Luciano Boschiero (2010), 'Translation, Experiments and the Spring of the Air' (pg. 70)

Chapter point: (add) [length: 8-pgs]

In Oct 1660 to Mar 1661, Christiaan Huygens, pronounced or 'high-gens' or 'ho-oue-gen', a Dutch physicist, inventor, astronomer, and mathematician, visited Paris, rubbing shoulders with the intellectual elite, such as Gilles Roberval and Blaise Pascal. Here, Huygens spent a good deal of time at the Montmor Academy, which was an intellectual salon, hosted in the home of wealth Henri Montmor, that ran from 1657 to 1664, prior to its falling out, thereafter becoming the forerunner to the Royal Academy of Sciences, the French equivalent of the English Royal Society. The Montmor group, which had weekly meetings every Tuesday, which Huygens attended, included: Pierre Gassendi, who prior to its formation donated Galileo's telescope to the group, which he had been given by Galileo, Pierre Huet, a noted early religio-mythology scholar, the vacuum experimenters: Pierre Petit, Gilles Roberval, and Adrien Auzout, along with Blaise Pascal in some connective sense.

The following is a key journal entry, of note, made by Huygens during this period, in that we hear talk of cannon barrels, steam, and flying:

> "Saw Chapelain, Conrart, Roberval. Didn't find Carcavy. The duc de Roannez came to see me, and Pascal later. Talked about the **force of steam in their cannon** and about flying. I showed them my telescopes."
>
> — Christiaan Huygens (1660), *Journal Entry*, Dec 13

The person Huygens talked to specifically about the 'force of water rarefied in cannons', has been conjectured to have been Pascal, whom in Dec 1660 Huygens met at the house of Duc de Roannes, and also Pascal, along with the Duke, eight days later, visited Huygens at his lodgings in rue Sainte Marguerite; this conjecture is summarized as follows:

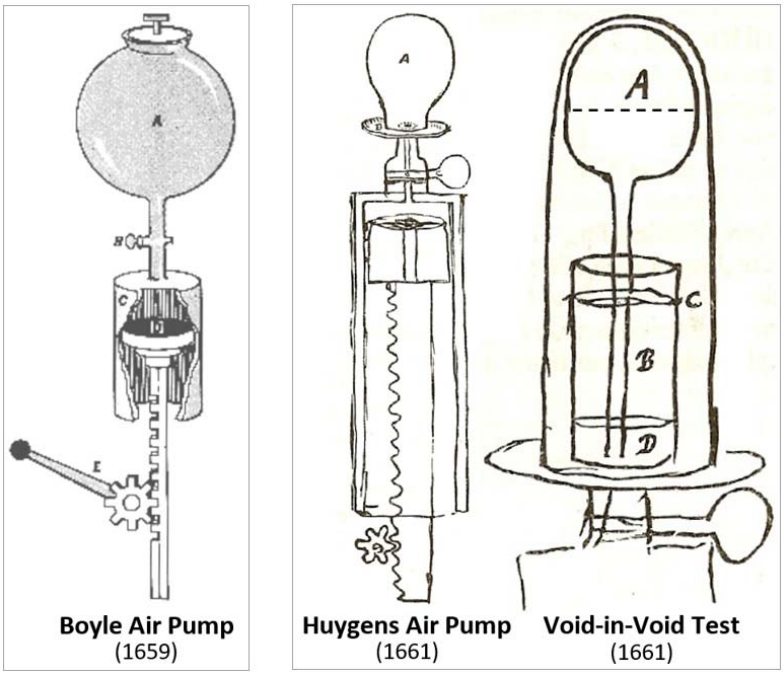
> "There is a possibility that Huygens had considered some kind of atmospheric engine as early as 1660 when he talked with Pascal about the 'force of water rarefied in cannons'. In these experiments of 1673, we can see the forerunner of Papin's atmospheric engine, which did in fact employ steam in place of gunpowder."
>
> — Arthur Bell (1947), *Christiaan Huygens* (pgs. 43-44, 74)

Pascal, however, was sick at this time, and semi-retired from academic affairs; as Bell points out, he was 'dead less than a year later', as Bell points out. Hence, it remains a potentially open question, as to who exactly Huygens was discussing the force of rarefied steam in cannons with?

In Apr 1661, Huygens moved to London to visit and meet with the scientists of the Royal Society, during which time Robert Boyle explained his vacuum experimental work to him, pointing out the device's many experimental possibilities. Huygens was particularly interested in Boyle's experiment #17, the so-called 'void within a void', previously done by the French, wherein Boyle had put a Torricelli barometer inside of his vacuum tube, and then pumped out the air, as he watched the height of the mercury column fall, until it was the same as the height as the mercury in the bottom tub, thus proving that it is the 'weight' of the atmosphere that holds up the mercury in the column of the Torricelli barometer.

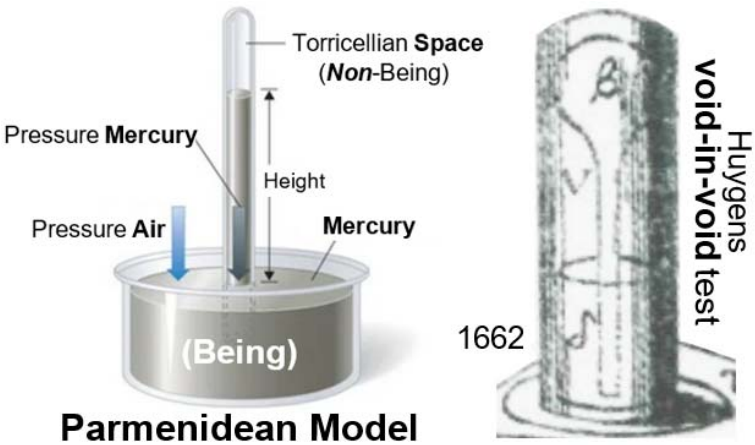
In autumn 1661, Huygens, after returned to Holland, had built his own vacuum pump, shown below adjacent middle and right, generally based on Boyle's design, below left. Huygens, with his own air pump, repeated Boyle's experiment #17, but this time he used water to make the barometer instead of a mercury barometer. Namely, as shown above right, he filled the bulb-shaped tube A with water, then inverted it into cup B also filled with water, at which point some of the water would drain out into the cup, but not all the way, stopping at the dotted line level in the bulb. He then, like Boyle, pumped the air out of the receiver,

and found, like Boyle found with mercury, the level in the bulb A to fall until it became the same level as the water in the dish:



Next, Huygens, noticing, like Boyle, that when was is 'exsuctioned', as Boyle would say, that bubbles appear in the water. Huygens, therefore, thinking that possibly 'air' was in the water, might be left behind in the so-called 'Torricellian space', i.e. the purportedly empty region left at the top of the barometer bulb, after it was inverted, which was said by the *vacuist* camp, i.e. new thinkers like Torricelli, Guericke, Boyle, to be devoid of all things, but said by the *plenist* camp, e.g. followers of Aristotle and Descartes, to not be a complete void or have something inside of it, like 'subtle matter' as Descartes claimed, decided that he would repeat the experiment, albeit this time using so-called 'purged' water, the exact details of which are wonting, but generally Huygens, as generally understood, put a cup of standard water in an evacuated receiver, for several days, so to let the bubbles out. This, supposedly, was thus purged air.

Huygens then repeated the vacuum in vacuum experiment, but this time with purged air. He found, strangely, that the boiled water, with no air bubbles in it, in the inside tube B, did NOT fall in height, when the outer receiver became evacuate?



Now, to pause, before explaining this, and repeat again, the reason why there was such intense focus on what *was* or *was not* in the so-called Torricellian space, is that if there was indeed a vacuum in the Torricellian 'space', then it would be possible, ontologically speaking for 'being' to go into 'non-being'; or as Aristotle said the *plenum* is 'being', the *void* is 'not being':

> "The '*plenum*' [space with atoms] and '*void*' [space without atoms], according to Democritus, exist, the one as '**being**', the other as '**not being**'."
> — Aristotle (350BC), *Physics* (§1.4)

Hence, for over 2,000-years, prior to these Boyle-Hooke vacuum within vacuum tests, the plenists were philosophically ensnared with the vacuists, and for most of these years, the plenist, having the church on their side, held the lead. In a sense, at least as per the then-current Parmenidean-based Aristotelean-Cartesian themed model in vogue, when you *ceased to exist*, i.e. 'died' in colloquial speak, what defined

'you', as a human *being*, at the exact moment of cessation, in the grand picture of things, would no longer exist; the theory of *continuity of being* would, in short, become dissolved or disproved; hence, the we witness the acute and peculiar focus on the Torricellian space.

Much of this 'hidden issue', so to say, was not always spoken about so openly, as they seem to have done in the days of Parmenides and Aristotle. One noted exception, however, was the famous collision between Descartes, who believed there was a 'subtle matter' in the space, Pascal, who was indecisive, but who, the following year (19 Sep 1648), as we have covered, orchestrated the mercury barometer mountain climbing test, and Gilles Roberval, a French mathematician, who had a standing grudge against Descartes, and who believed Torricellian space was indeed empty, but that height of the mercury column depended on the limit of the natural abhorrence of vacuums; the following is a summary of this 'collision of geniuses', as reported by Pascal's sister:

> "They began to discuss the problem of the vacuum. **Descartes** became particularly serious on the subject. The others explained a recent experiment to him and asked him what he thought entered into the space of the emptied tube. He said that it was his 'subtle matter'. My brother [Blaise **Pascal**] responded to this theory as best he could. Believing that my brother was having some difficulty expressing himself, **Roberval** took on Descartes with not a little passion, although he remained civil. Descartes responded rather bitterly that he could speak to my brother as long as he desired because my brother spoke reasonably but that he wouldn't continue to talk with Roberval, because the latter spoke out of too many prejudices. With that, he glanced at his watch and saw that it was noon. He stood up, because he had a dinner date in the Faubourg Saint-Germain."
>
> — Jacqueline Pascal (1647), 'Letter to [Name]', Sep 15

So, in other words, the question of what *was* or *was not* in the Torricellian space, was the one question on the minds of all the biggest thinkers of the era. Hence, when Huygens used 'boiled water', in his barometer, for his second void-in-void experiment, he was looking to solve, definitively, this ongoing two-millennia long debate.

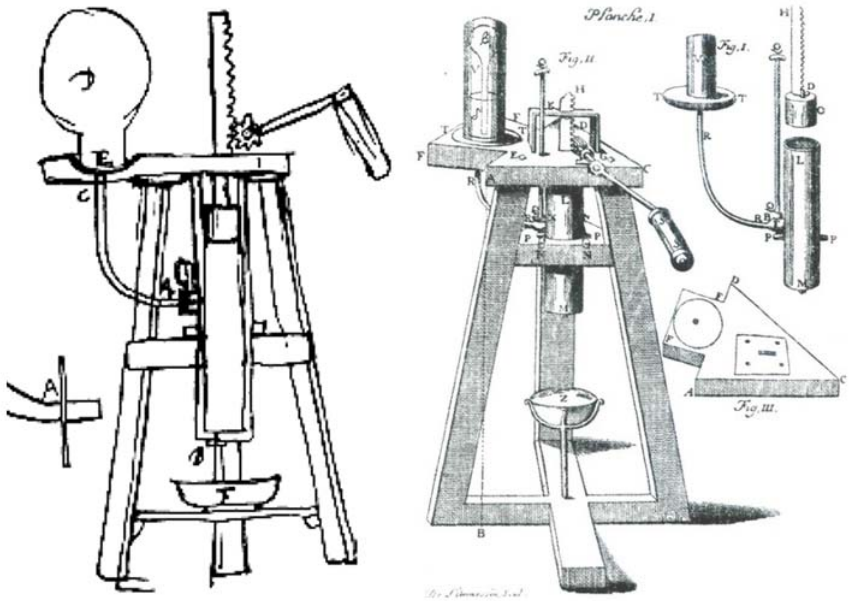
Subsequently, when Huygens found that the water column, made of *purged* water, did NOT fall, like normal water, or like mercury, he reported his findings back to Boyle, Boyle initially denied the effect because he could not reproduce it with his own air pump. Boyle also suggested that Huygens pump could not evacuate sufficiently. Huygens, in turn, believed that Boyle's pump was defective.

The demonstration of 'anomalous suspension' was finally demonstrated in London, in 1663, in front of the Royal Society, debates about what was occurring here ran through various scientific circles, into the 1670s, eventually came to a sort of unresolved issue; the standing view being that it has something to so with extra molecular adhesion in the airless water and bubbles forming in the normal tap water, which rose during successive evacuation pumps.[2]

15.1 | Second generation vacuum pump

In 1662, Huygens made 'second generation' vacuum pump, as shown below, which shows the vacuum in vacuum test of the receiver containing the barometer, seen in the previous diagram. This new design also has an inverted piston and cylinder, which was filled with water on the backside of the piston, which has a drip tray F, shown below, thereby, in theory, making a better seal.

In this new design, the tube A connect the side of the cylinder to the receiver or vacuum bulb at points C



Huygens Inverted Piston Vacuum Pump Design
(1662)

and E, and the receiver is removable, so that different sized bulbs could be employed for different experiments.

In 1663, Huygens got the Montmor group, to build a vacuum pump using this design, so that the vacuists there could begin conducting their own vacuum experimentation research program. Huygens continued his vacuum research using this device until at least 1668.

15.2 | Gunpowder Engine (1673)

Huygens, as we have mentioned, in 1660, had begun discussing, with the Montmor group, while in Paris, speculative ideas about using a cannon and the force of steam to make some sort of engine, possibly. We also know that in 1661, he had mentioned the possibility of using a cannon, steam, and heat, to raise a weight. Two years later, however, after learning about Boyle's model of making the vacuum space of a piston and cylinder engine raise a weight, he gleaned on the idea that he could use gunpowder to make a vacuum inside of a piston and cylinder, so to raise a weight.

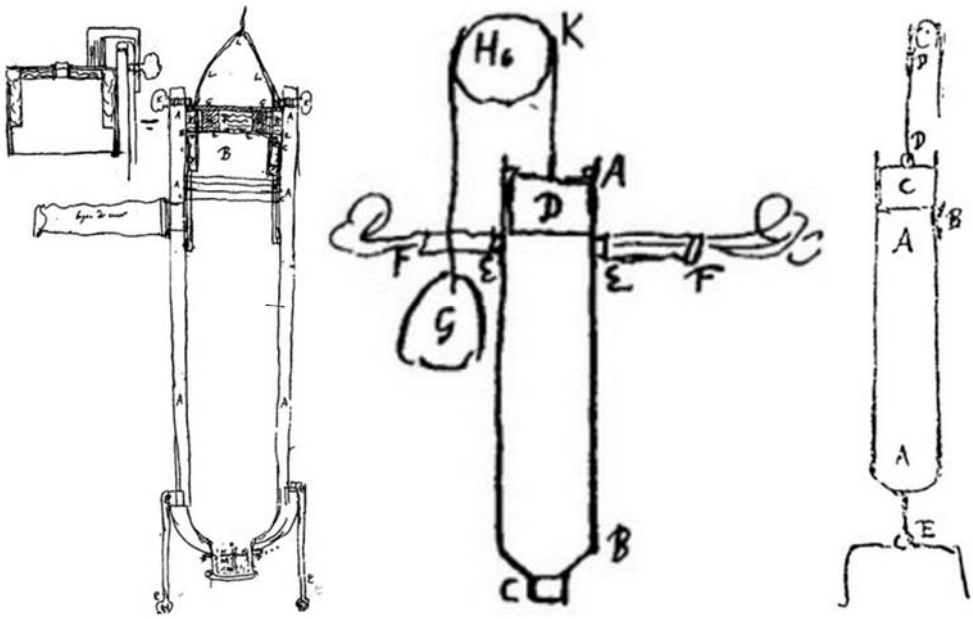
In Feb 1673, Huygens reported that he had 'constructed an engine', built using a small cylinder, according to which by means of gunpowder, he was able to obtain a new motive power, i.e. to lift a weight in a vertical distance:

> "I have **constructed an engine** for obtaining a new motive power by means of gunpowder and the pressure of air."
>
> — Christiaan Huygens (1673), *Oeuvres, Volume 22* (pg. 241), Feb 10; cited by Joseph Needham (1987) in *Science and Civilization in China: Volume 5, Part 7* (pg. 556-57)

Another take on this new Feb 1673 engine, is as follows:

> "Huygens calculated that a single pound of gunpowder could raise 3,000 pounds a distance of thirty feet. In a 1673 experiment he managed to lift a weight using a small cylinder."
>
> — Jack Kelly (2009), *Gunpowder* (pg. 118)

Said another way, Huygens calculated, supposedly, that a single pound of gunpowder possessed enough energy to raise 3,000lbs 30 feet and that a 3ft diameter cylinder would give upwards of 40 horse power (HP), according to Joseph Needham's footnoted translations; although, to note, 'HP' or horsepower was not yet an invented unit in this century. The following are three different draft sketches for Huygens' gunpowder based *new motive power* machine, which he was circulating, in his 1673 communications and publications:[3]

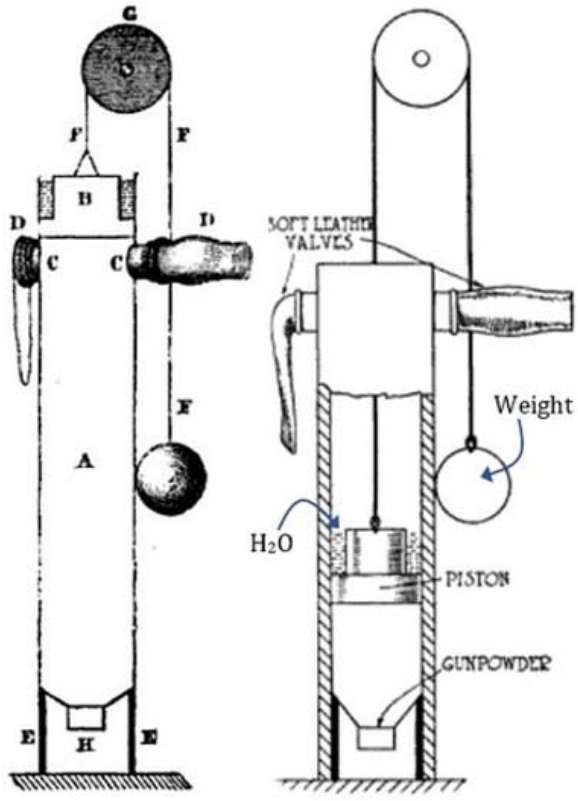


Here, we see that Huygens, independently, employing the cannon barrel explosion, with one-way 'out valves', that Da Vinci employed in 1508.

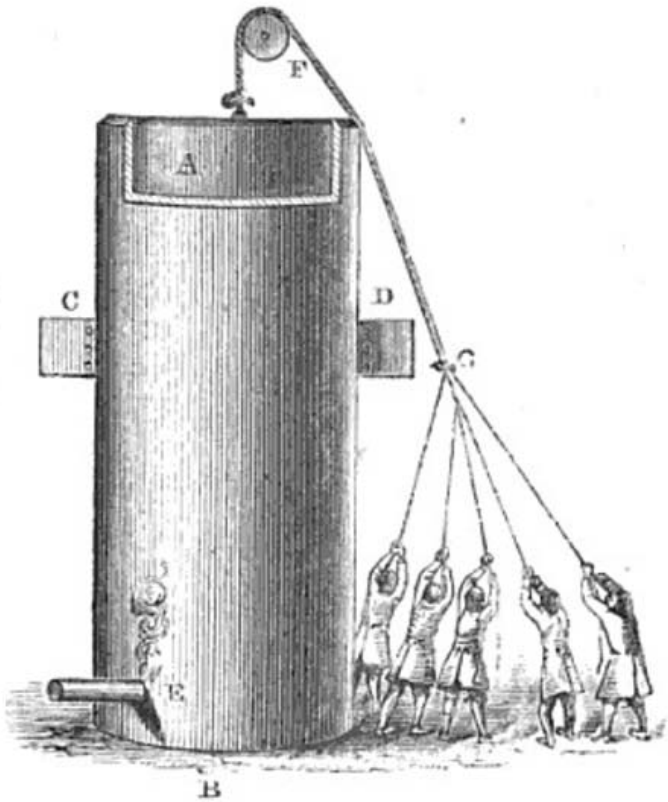
To operate, one places gunpowder inside the cannon, lights or detonates the gunpowder, it explodes, the solid gunpowder transforms into gaseous products, the product gasses escape through the vents, such as the left tube, above left, the two ports F, above middle, or vent B, above right. Once the gases have escaped, the inside volume of the cannon, e.g. region A and A, above right, becomes a partial vacuum, in respect to the surroundings, or pressure of the atmosphere. The piston, B, above left, D, middle, or C, right, accordingly, is 'forced' down, by the pressing weight of 62-miles of air molecules above its surface, in respect to the few remaining molecules inside the cannon. When the piston descends, a rope attached to a pull, lifts a weight, or does 'work' in modern parlance. Heat engine theory 101, as we might say. Huygens commented on this new invention:

> "The force of cannon powder [gunpowder] has served hitherto only for very violent effects such as mining, and blasting of rocks, and although people have long hoped that one could moderate this great speed and impetuosity to apply it to other uses, no one, so far as I know, has succeeded in this, or at any rate no notice of such an invention has appeared.."
>
> — Christiaan Huygens (1673), *Publication*; cited by Joseph Needham (1987) in Science and Civilization in China: Volume 5 (pg. 557)

In 1678 to 1682, Huygens had progressed into the following modified working model of gunpowder engine designs:



Huygens Gunpowder Engine
(1678)

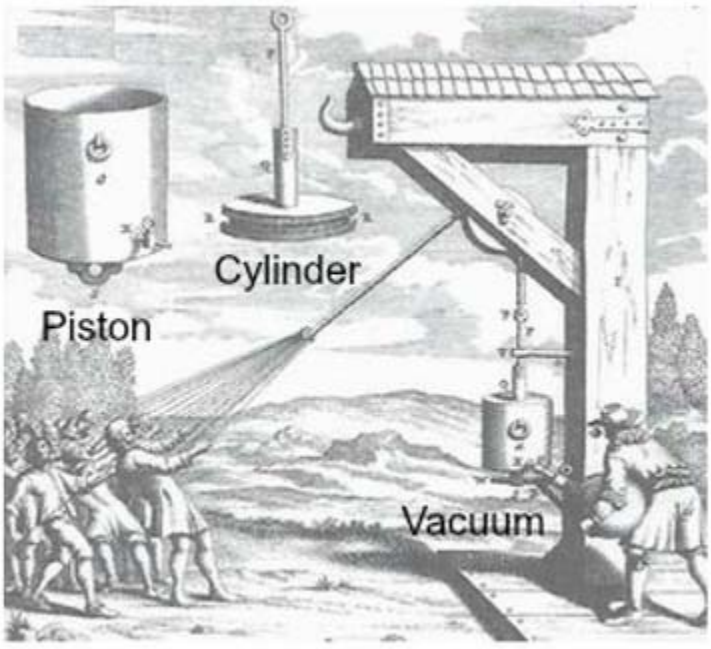


Huygens Gunpowder Engine
(1682)

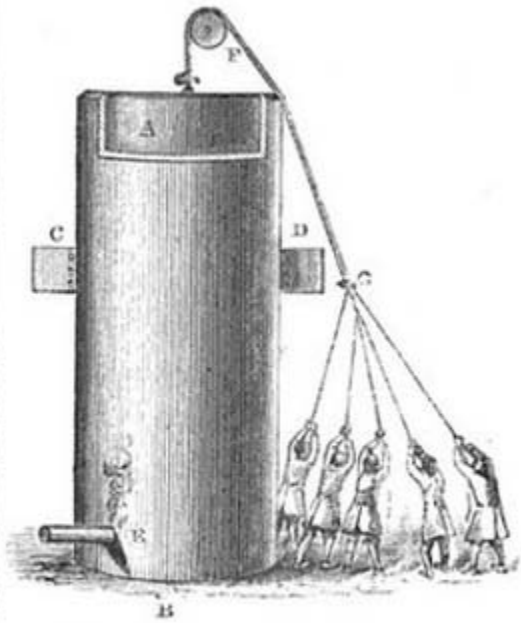
Above right we see that the explosion of the gunpowder, in the cylinder, creates a vacuum inside the enclosed region or 'system' of the volume contained within the piston and cylinder; this forces the piston A down, and lifts 5-men into the air. Guericke commented on this:

> "I have seen some surprising effects in raising weights and men pulling the rope. If we could well see the air it would be much more."
>
> — Name (c.1675), *Publication* (pg. #)

At this point, we can now compare the Guericke 1654-1655 vacuum-effected rope pulling demonstration, with the 1682 Huygens vacuum-effected rope pulling demonstration; as shown below:



Guericke experiment
(1654)



Huygens experiment
(1673; 1682)

In respect to the similarity of these two publicly-popular experimental demonstrations, we do know that in 1659, Huygens had received a copy of Gaspar Schott's *Mechanical Hydraulico-Pneumatics* (1657), which contained an appendix 45-page summary of Guericke's early vacuum experiments.[5] The only actual image this book contains, in reference to Guericke, is his second generation vacuum pump. Moreover, the text is in Latin, and in need of English translation, so it is difficult to if Schott talks about Guericke's 20-man rope pulling demonstration. The actual illustrated Guericke rope pulling experiment, aka 'take your breath away' experiment, shown above left, was published in the 1672 *New Magdeburg Experiments: on the Vacuum of Space*. Either through this latter publication, or via word of mouth, it is likely that Huygens had learned about Guericke's early rope-pulling demonstration, and wanted to repeat the experiment, and show that the same effect could be obtained via gunpowder.

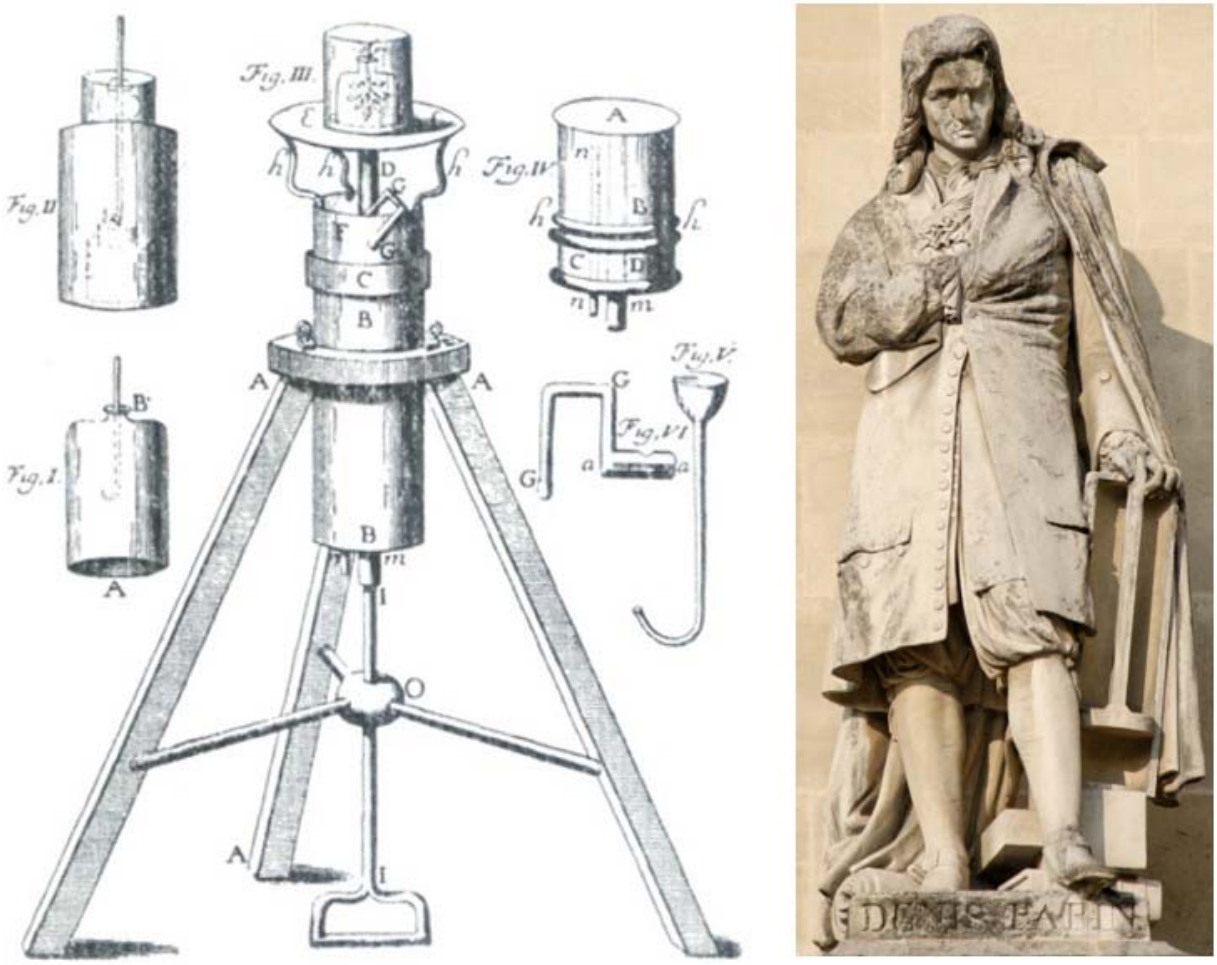
15.3 | Papin as Huygens' Assistant / Papin vacuum pump

In 1673, Denis Papin, a French intellectual, and newly-minted MD, aged 26, born in 1647, the year, as some have pointed out, when Guericke invented his vacuum pump, then interested in the possibility of preserving food stuff in a vacuum, became Huygens assistant. Papin, as we will shortly see is a peculiar figure, who plays out significantly in the theoretical development and eventual construction of the piston and cylinder heat engine, the forerunner to the Carnot theoretical heat engine, and hence thermodynamics.

Both Huygens and Papin, to keep readers into the context of the cultural atmosphere at the time, were French Huguenots, namely French Protestants who held to the reformed, or Calvinist, tradition of Protestantism. The Huguenots had coexisted with French Catholics since the Edict of Nantes (1598) had certified their freedom of religious practice. But, after a rapid buildup of anti-Protestant sentiment, Louis XIV repealed the Edict in 1685, after which some four-hundred-thousand Huguenots were expelled from France. They had to move off into Germany, England, Canada, and American, e.g. Alexander Hamilton and Paul Revere ended up in Massachusetts. Papin, as we shall see, in the wake of the Edict of Nantes, ended up in Germany, where the first prototype to the Carnot engine was constructed and demonstrated.

Over the course of the year, Papin built a redesigned vacuum pump, as shown below left, which was basically the same as Huygens's first-generation vacuum pump, albeit with the additions of having two pistons on one rod, the lower piston carrying a quantity of water that sealed off leaks in the top piston, and the piston rod was connected to a 'stirrup' I, designed to be worked with one's foot, so to make the task of pumping less tiring, thus also leaving one hand free to operate the cock. The cock itself being a special three-way-cock, with a combined inlet valve and outlet valve, which was easier to handle than a separate

inlet-cock and stopper. Also shown, below right, we see a statute of Papin, as found on the second story ledge of the Louvre Museum, among statues of great French thinkers -- Descartes, Diderot, Voltaire, wherein Papin is shown holding a sectioned piston and cylinder, namely a cylinder, cut away to expose a piston and rod within it:



This vacuum pump design of Papin's, is largely a reconstruction of Huygens' first vacuum pump design, but had the additions that it was also able to work as a compressor, an air pump and vacuum pump combination. We also see, in this illustration, in figure 3, or the receiver bulb at the top of the device, Papin doing some type of a plant in a vacuum test, which seems to have been a great interest of his during this decade; which, as we see, is something he carried forward in his work with Boyle from 1676 1o 1680.

In 1674, Papin, under Huygens supervision, published *New Experiments on the Void* (*Nouvelles Experiences de Vuide*), a summary of the vacuum experiments he had observed, learned about, and did, such as with this new vacuum pump, under his apprenticeship with Huygens, which included Huygens' designs of vacuum pumping machines, including tests and animals and plants inside the vacuum, and the barometer inside the vacuum, which was printed in French in Paris.

In 1675, Huygens and Papin jointly five papers in the *Philosophical Transactions*, on Huygens' vacuum research.

In Jun 1675, Huygens received a printing of Boyle's collected papers, and in return, the following month, Huygens sent Papin to England with his own air pump to engage with Boyle directly. Papin carried a letter of introduction from Huygens to Henry Oldenburg, the secretary of the Royal Society, declaring Papin's interest to learn what the English experimenters were doing:

> "Papin carries with him our book *Nouvelles Experiences de Vuide* (1674), and his wish is to 'see what is being done in your country, even with the plan of establishing himself there if he can find the opportunity. I beg of you kindly to grant him your favour and protection, and that by your means he may be known by your illustrious friends, above all Mr. Boyle and Lord Brouncker'."
>
> — Christiaan Huygens (1675), "Letter to Henry Oldenburg"

Oldenburg gave Huygens a starter job as a tutor. Huygens, after spending a few months learning English, shortly thereafter became Boyle's assistant, Boyle first employing him to make a translation of a theological treatise, then later making him curator of his experiments, under whose tutorage he remained over the next four years.[4]

Synopsis: (add)

References

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2. http://www.eoht.info/page/Anomalous+suspension
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4. Boschiero, Luciano. (2009). "Translation, Experimentation and the Spring of the Air: Richard Waller's Essayes on Natural Experiments", *Notes and Records*, Royal Society, Oct 14.
5. Bell, Arthur. (1947). *Christiaan Huygens: and the Development of Science in the Seventeenth Century* (cannons, pgs. 43-44, 74; Schott's 1659 book, pg. 44)). Read Books, 2012.
6.

16. Papin

“.”
— Author (date), *Publication*

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In Jul 1675, Denis Papin, after apprenticing under Christiaan Huygens, for the previous two years, working on and writing about gunpowder engine testing and vacuum pump experimentation, travelled to England, with his own vacuum pump and letter of introduction from Huygens, and was received by Henry Oldenburg, the Royal Society secretary, who gave him a job as tutor.

By Autumn 1675, Papin, after spending several months learning English, began to resume his previous work with the vacuum pump, so to acquire Boyle’s attention. To facilitate this connection, Papin and Huygens, as mentioned, published a series of five papers in the *Philosophical Transactions*, wherein they narrated some of the vacuum experiments covered in Papin’s *New Experiments on the Void* (1674), with the underlying aim to awaken the Royal Society to the work they had done in Paris, and more importantly to alert Boyle to Papin’s presence.[1]

In Feb 1676, the last of these papers went to print, and Oldenburg read an account of Huygens’ and Papin’s experiments at a meeting of the Royal Society, where some of their experiments were replicated. The ruse worked, and Boyle, shortly thereafter offered Papin a job as his assistant; at first to do a translation of a theological treatise, then later as Boyle’s new experimental curator.

Boyle, who recalls first meeting Papin ‘seven or eight years’ after the publication of his *Continuation of New Experiments* (1669), i.e. in the years 1676 to 1677, later reflected on his first meeting with Papin as follows:

> “At which time it happened very opportunely, That a certain tract [*Nouvelles Experiences de Vuide*, 1664] written in French, small in bulk, but very ingenious, containing sundry experiments concerning the preservation of fruits, and some other tracts of a different nature, was brought unto me by monsieur Papin, who had joined his pains with the eminent monsieur Christian Hugenius, in making the said experiments.”
> — Robert Boyle (c.1685), *Collected Works* (pg. #)

Over the course of the next four years, 1676 to 1680, Boyle employed Papin as his chief curator of experiments, and together they conducted further experiments on the vacuum.

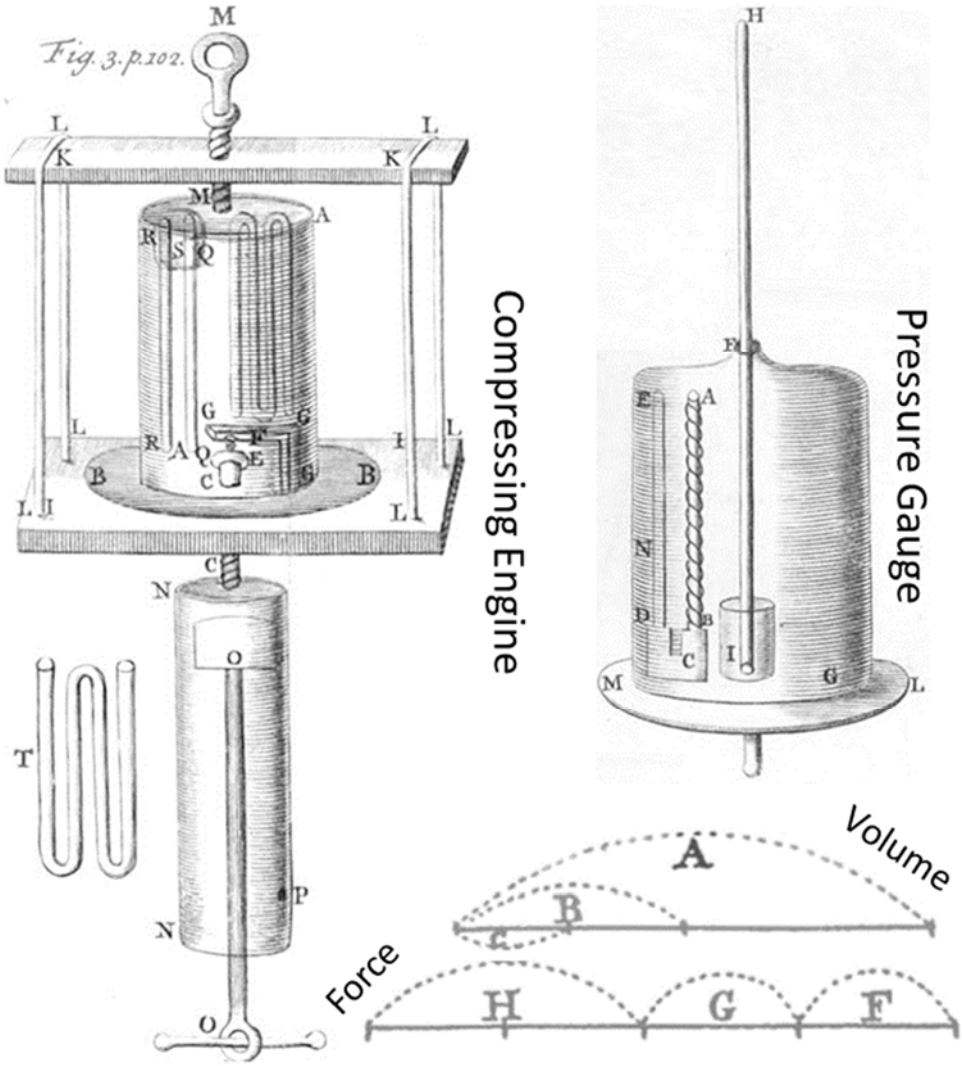
In these years, Boyle was interested no longer on vacuums, via expansion of air, but on the study of compression of air, the reverse of the former. Papin, however, was interested in the preservation of food stuff, such as plants and animals, in a vacuum, so the research that ensued was a combination of both of these, vacuum research and compression research.

In 1680, Boyle, having been forced to rest because of an illness, had Papin write up a summary of the new vacuum experiments that they had been conducting, which was first written in French, Papin’s native language, then printed that year in Latin, and translated into English in 1682, entitled *A Continuation of New Experiments Physico-mechanical, Touching the Spring and Weight of the Air, and Their Effects: Wherein are Contained Divers Experiments: Together with a Description of the Engines Wherein They Were Made. The Second Part*, which details various experiments conducted by Papin under the direction of Boyle, some of which including the preservation of grapes and bread, to check for air release over the course of many days. Many of the experiments are dated to the day.

16.1 | Papin as Boyle’s Assistant / Compressing Engine

The following diagram, from this this Boyle-directed, Papin-written *A Continuation of New Experiments Physico-Mechanical, The Second Part*, shows Boyle’s compressing engine, below left, designed to increase pressure in the receiver bulb, an example of which as shown below right, in which, shown by figure ABCDE is Boyle’s new mercury pressure gauge. The pressure gauge, consists of glass tube AB, which is open at A. This tube is connected, at location B, to a u-shaped tube BCD, which contains mercury, which in

turn is connected to tube ED, which is sealed at the top at E. The figure the long tube HI is an inverted mercury column into cup of mercury, i.e. a Torricelli barometer. Both of these devices are sealed into receiver bulb G, which rests on plate LM, below which is a valve that pumps air into the receiver, so to increase the pressure. The pressure in the receiver is measured by change in the 'spring of the air', or volume change of tube ED, the applied pressure:



Boyle uses this new device to make the force (or pressure) vs volume diagram, shown above. Here, A represents a certain quantity of air, in tube ED and F is one unit of 'compressing force', supposedly being one compression stroke of his pump. If the force is doubled to 'F + G', then the volume of the air is halved to B. If the force is increased to 'F + G + H', the volume is reduced to a quarter of A, shown by curve C. Thus, Boyle, or more correctly Papin, summarizes this as follows:

> "The remaining space will be in the same proportion to the total space, as the first pressure is to the total pressure. It is evident, from the experiments long since published by Mr. Boyle, in his answer to Linus, that the space possesses by the air, is diminished in the same proportion, as the compressing force, and vice versa."
>
> — Denis Papin (1680), *A Continuation of New Experiments, The Second Part* (pg. 101)

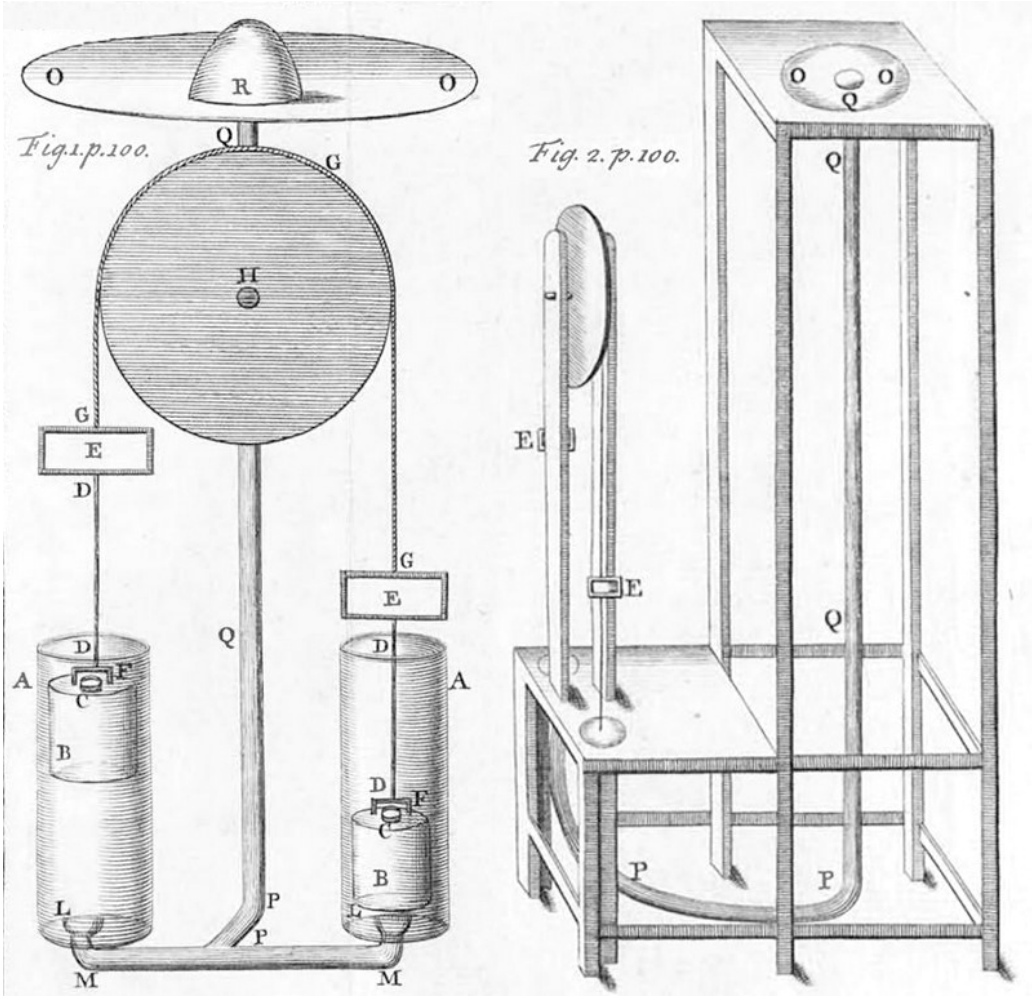
Here, of course, as we have covered this is Power's law (1661) or Power-Boyle law as we named it. Boyle here, accordingly, has devised an experimental way to measure these changes in pressure with volume incrementally, using an experimental device.

In 1679, Edme Mariotte, of related note, working at the Royal Academy in Paris, published in his *Discourse on the Nature of Air*, wherein he referred to the finding that pressure is inversely proportional to

volume, as a ‘law of nature’; hence, one can occasionally find references to this law as the Boyle-Mariotte law.

16.2 | Double Barrel Vacuum Pump (1677)

In 1677, Papin built a double barrel vacuum pump, as shown below, as described in *A Continuation of New Experiments, The Second Part*, made a double barrel air pump, which had ‘self-acting valves’, unlike the early Boyle model, where the operator had to turn the inlet-outlet ever exsuction, that were operated by turning a wheel, the use of two barrels employed so that the time to achieve a vacuum was reduced:[2]



In this new vacuum pump design, A and A are two ‘pumps made of brass’; presumably the cylinders. Part B and B are ‘two plugs hollow within, and open below’; presumably these are the pistons. C and C are ‘two holes in the upper part of the plugs, with valves opening outwardly, that they may afford passage to the air to go out, and hinder it from coming in’. The cords DD and DD are ‘iron rods serving to move the plugs, and annexed to them, by means of gnomons FF’. The rectangle shapes E and E are ‘two flat iron stirrups at the top of the rods DD, on which the operator must stand to set a work on the engine’. Here, we see this is a continuation of Papin’s first generation vacuum pump, wherein he employed one stirrup.

The rope GGG is a cord joining the two stirrups, which encompass a pully H. At the bottom of the cylinders are two valves L and L, that open inwardly, for the ‘admission of the air out of the tube MM’. This tube MM connects to tube PQ, which connects to a plate OO, and through a small hole to the receiver bulb, such as R, as shown, which is removable.

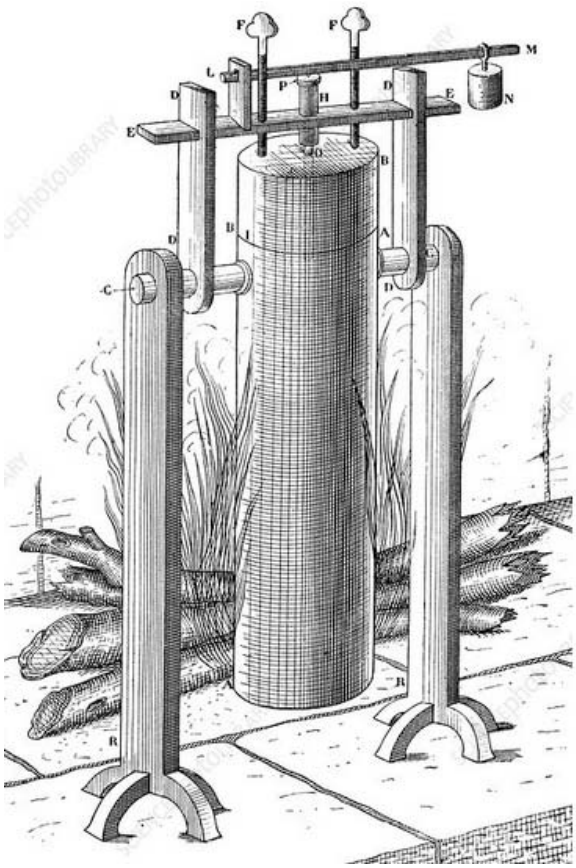
This pump is then fitted into the wooden frame, shown at right, labeled as figure two. Then to operate this engine, water is first poured through the hole Q in the plate OO into the pumps, as is ‘sufficient to fill the cavities of the plugs, and a little more’. Then someone must stand on the two iron stirrups EE and alternately depress and elevate them, like one of those ladder-climbing exercise machines in modern gyms.

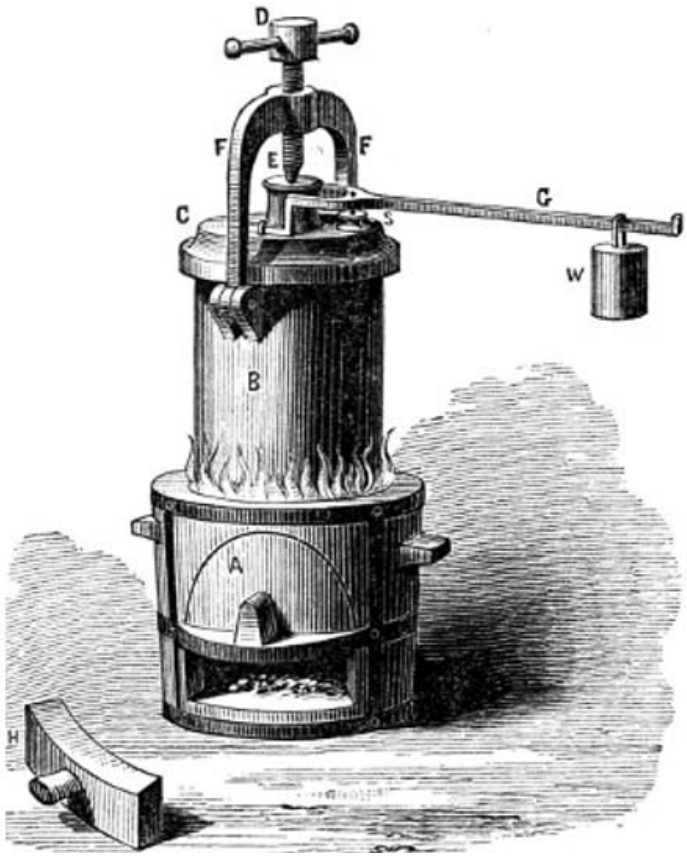
Doing this, skipping a few details, eventually works to evacuate the air from the receiver, making a vacuum therein.

16.3 | Digestor (May 1679)

In 1678 or early 1679, Papin was experimenting with food again, only this time in respect to the compression of food stuff in steamed volume. He seemingly was aiming to make a pressure cooker of some sort. Early attempts at this new device resulted in explosion, owing to the extreme pressures. He fixed this problem by adding on steam release valve.

On 22 May 1679, Papin had finished building a 'digestor', or apparatus for boiling food under pressure cooker, which was able to liquify bones or rather turn bones and horns into a soft cheese like substance, which he then presented to the Royal Society; the following are two variations of this so-called Papin digestor:





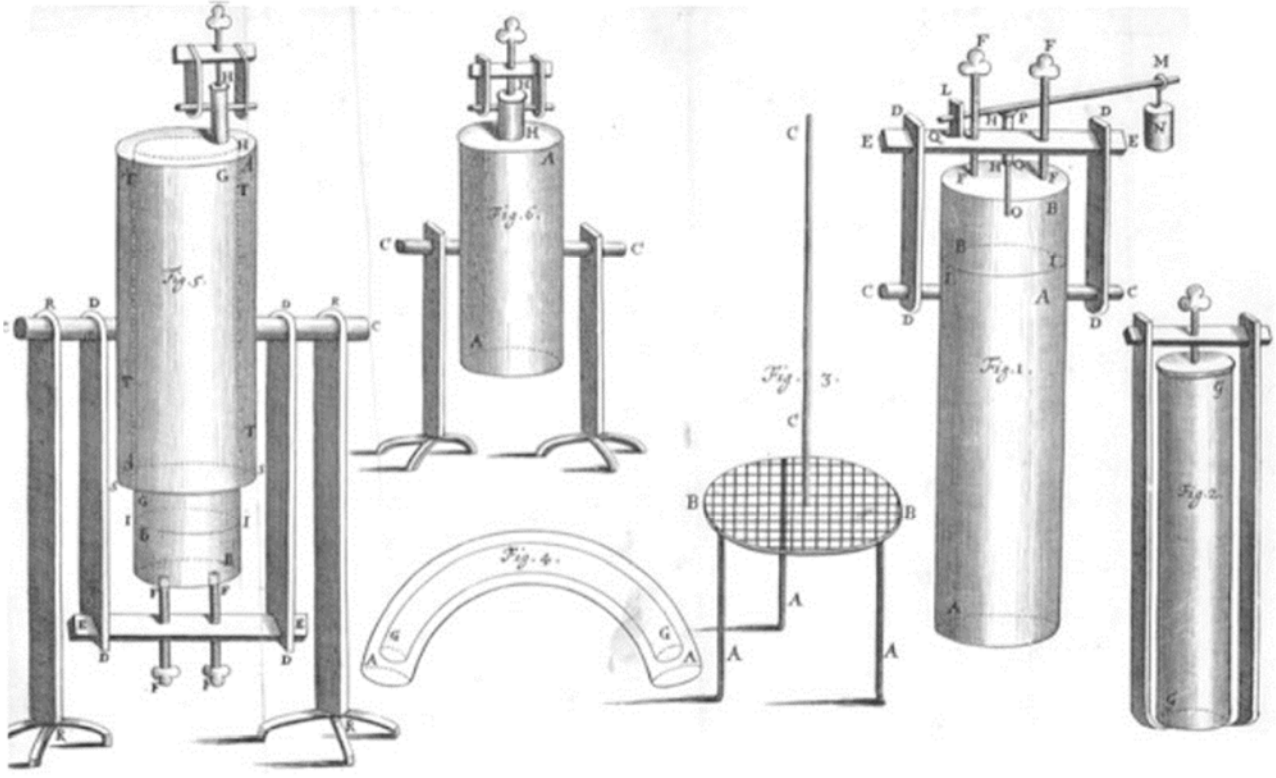
In 1680, Papin printed a fifty-page booklet entitled *A New Digester or Engine for Softening Bones: Containing the Description of Its Make and Use in These Particulars: viz, Cookery, Voyages at Sea, Confectionary, Making of Drinks, Chymistry, and Dying*, which include an overview the design, specifically the above left design, and operation of his new pressure cooker; commenting the following:

> "I may besides say, that this was no hard matter; for everyone knows that compact bodies, if hot, will burn more powerfully than those of a more rare contexture: that red-hot iron, for example will do more than coals: so there was no question but that water being heated enough for boiling, and shut up so as not to be able to expand itself, as by ebullition it doth, such water, I say, would effect much more than if permitted to its ordinary boiling expansions. For my part, as soon as this came to my mind by making some experiments about compression for Mr. Boyle, I thought it so certain, that I made no question to undertake a trial: yet though the thing was so easy, no body, that I know of, had any thoughts of it: many learned men have don and do still things of much more difficulty, but nobody can see all things. Therefore, we must confess, that there may still remain discoveries to be made by small as well as great capacities."

— Denis Papin (1680), *A New Digester or Engine for Softening Bones* (§: Preface)

Papin, in this booklet, devotes sections to 'how to know the degree of heat'; 'experiments made upon bones', 'how to boil beef', 'horn turned like parmesan cheese', and 'how to make tortoise shell soft for a great while', among others.

To give a quick overview of the operation of Papin's 'bone softening engine', the following is a more detailed illustration of his device, which he covers in detail in his *A New Digester or Engine for Softening Bones*. In short, he takes a large outer cylinder, sealed at one end, into which he puts a smaller cylinder, in the shape of an elongated piston of sorts, which is tightly fitted to the outer cylinder. To this smaller cylinder, he fixes two screws F and F, which when turned work to compress or push the smaller cylinder into the bigger cylinder. The food stuff, along with water, is place inside of another glass cylinder shaped vessel, which fits into these to cylinders, in some way. Fire is then started around the device, flames rising up to the level of the device resting arm C and C.



To keep track of the pressure inside the device, a small tap hole is drilled at location H, which shoots a small amount of pressurized steam onto the pressure-measuring arm LM, according to which the location of the balancing weight N along arm LM gives a reading of the pressure.

Papin, of note, in commentary on how in many early versions of this engine and or attempts at cooking, sometimes meat would be taken out too soon, or left in too long and burn, makes recourse to Boyle's compression experiments to make a calculation of the heat and the pressure inside of the digestor. He explains his pressure measuring device as follows:

> "It was therefore necessary to find out some way how to know the quantity of 'inward pressure', and the 'degree of heat'. To know the quantity of inward pressure, you must have a little pipe open at both ends, as HH: this being soldered to a hole in the cover BB, is to be stopped at the top with a little valve P exactly ground to it, and fitted also with a paper between. Now, according to the physico-mechanical experiments of Mr. Boyle, the ordinary pressure of air against a hole one 1 inch over is about 12 pounds, and therefore it is about 2 pounds against the aperture of said pipe HH. the rod LM is 12 inches long, and the distance from L to P is 1 inch; so that 1 pound weight hanging at M, presses as much upon the valve P as 12 pounds could do, if directly laid upon the said valve; and so it cannot be lifted up, unless the inward pressure be six times stronger than the ordinary pressure of air. Therefore, when there is one pound weight hanging in M, and yet the water gets out under the valve, one may conclude that the inward pressure is about eight times stronger than the ordinary pressure of air."

— Denis Papin (1680), *A New Digester or Engine for Softening Bones* (pgs. 2-3)

He explains his heat measuring device as follows:

> "To know the degree of heat. I wish I had been able to make a thermometer divided as it should be, to shew precisely by how much the heat is increased or diminished: and l believe by that means , comparing the several degrees of heat with the quantity of the effect thereby produced, one might discover several things about the 'nature both of heat and of the materials wrought upon': but for want of time and other necessaries for that design, I have instead of it used another very easy, and yet exact enough for all the uses here spoken of. I hang a weight to a thread about three feet long, so that every swing makes about a second , and l let fall a drop of water into a little cavity made for that purpose at the top of it, and I tell how many times the hanging weight will move to and fro before the drop of water is quite evaporated: and l take care that the place where l put the drop may be clean, because a little grease will considerably hinder its evaporation."
>
> — Denis Papin (1680), *A New Digester or Engine for Softening Bones* (pgs. 4)

Papin concludes by saying that 'so being able to know the degrees both of heat and pressure in the engine, one may easily order it so as to do the effect just as desired.

By 1682, some of the Royal Society's dinners were famously being cooked in Papin's digestor, the flavors digested bones in food, becoming legendary; the following being one take on these meals:

> "I went this afternoon with several of the Royal Society to a supper which was all dressed, both fish and flesh, in Monsieur Papin's digestors, by which the hardest bones of beef itself, and mutton, were made as soft as cheese."
>
> — John Evelyn (1682), Diary Note, Apr 12

Now, of importance with respect to the development of thermodynamics, French chemist Antoine Lavoisier, in his 1787 *Elements of Chemistry*, in his opening pages, cites what he refers to as 'Boerhaave's law', namely the c.1730 purported axiom professed by Herman Boerhaave, during his chemistry lectures at Leyden University, that all bodies are expanded by heat and contracted by cold, and Papin's digester as experimental proof of Boerhaave's law, in the sense that that 'stones may be turned to vapor', as Lavoisier sees things:

> "That 'every body, whether solid or fluid, is augmented in all its dimensions by any increase of its sensible heat', was long ago fully established as a physical axiom, or universal proposition, by the celebrated Boerhaave. It is easy to perceive that separation of particles by heat is constant and general law of nature."
>
> — Antoine Lavoisier (1787), *Elements of Chemistry* (pgs. 1-2)

In other words, in modern terms, Lavoisier summarizes the model that heat can be used to actuate or bring about phase change, thus credits Boerhaave and Papin as establishing principle of the augmentation of the dimension of bodies by heat as a universe rule. It is upon this Lavoisier-Boerhaave-Papin principle of heat expansion and contraction of bodies that, as we will see, Sadi Carnot, in 1824, formulated the Carnot cycle.

16.4 | Papin as Hooke's Amanuensis (Jul 1679)

In Jul to Dec 1679, Papin, in the months just after having invented his digestor, was employed as Robert Hooke's amanuensis, meaning he was a literary or artistic assistant, who took dictation or copied manuscripts. The specifics of what exactly Papin did for Hooke at this point are wanting. The point in introducing this section, at this point, is that, as mentioned, four years earlier Hooke had published the following so-called secret principle of nature, albeit in the form of a coded anagram, for him to unveil in the future should anybody 'claim discovery' of a principle he had already thought up, which is a reoccurring theme throughout Hooke's career:

> **"The vacuum left by fire lifts a weight."**
>
> — Robert Hooke (1675), *Description of Helioscopes and Other Instruments* (pg. #)

So, although we can only speculate, it would seem likely that Papin during his interaction, as assistant for Hooke, would have either probed him with questions, and or possibly have had some of Hooke's passing remarks or comments rub off on him? The following is one take on this interaction:

> "In 1679, Hooke worked closely with Papin on this topic. In May that year Hooke gained permission for Papin, not yet a Fellow, to perform an experiment at a meeting of the Society, with his newly invented food digester. During the following months, Papin and Hooke spent a great deal of time together testing the Boyle–Mariotte law. A relationship therefore emerged between Papin and Hooke on the basis of their shared interests in pneumatics."
>
> — Luciano Boschiero (2009), 'Translation, Experimentation, and the Spring of the Air' (pg. 74)

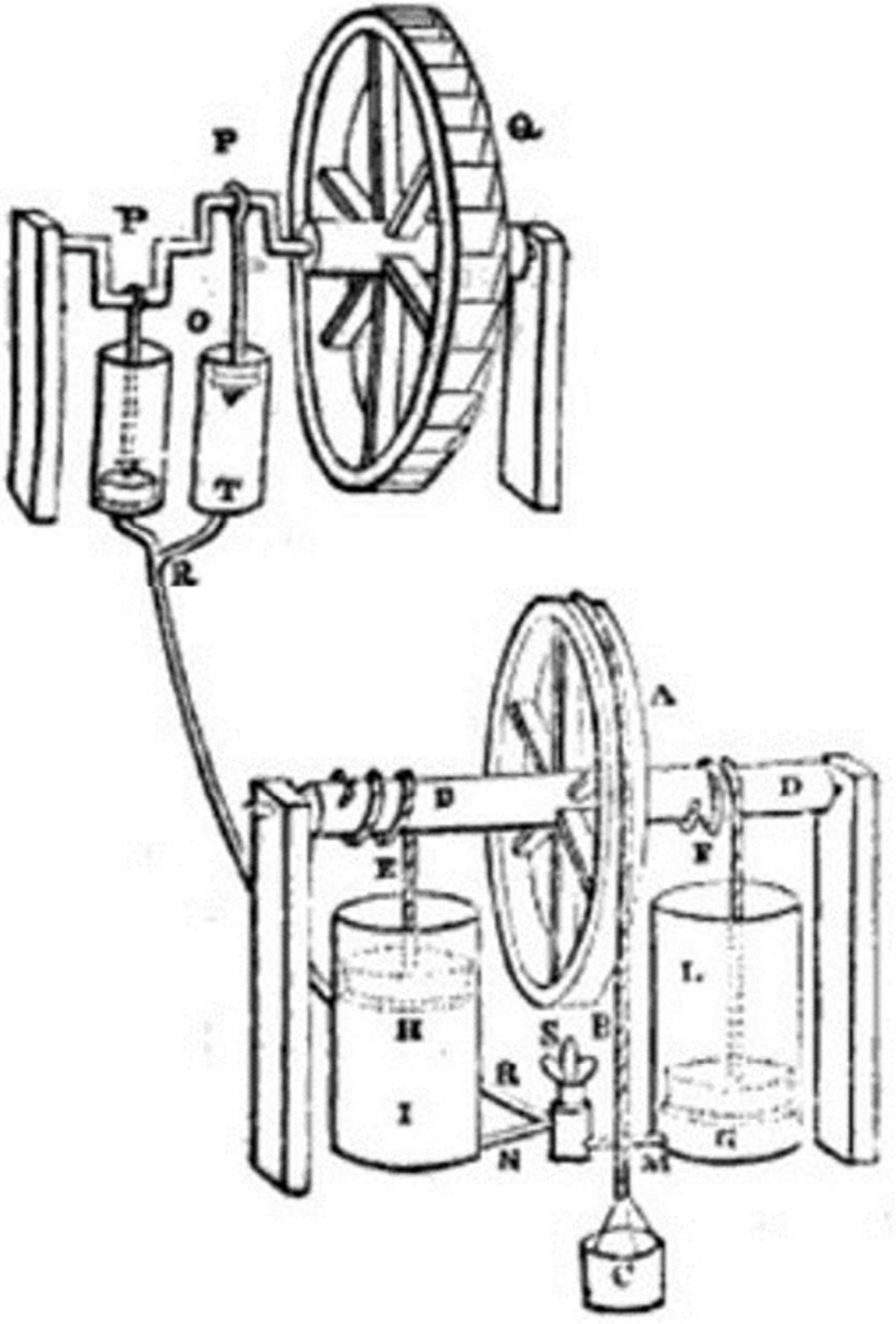
Whatever the case, most of which owes to Hooke's tiresome secrecy, it would be Papin, who, fifteen years later, brought this 'vacuum left by fire lifts a weight' so-called Hookean vacuum principle into the realization stage.

In 1681, Papin, after becoming a Fellow of the Royal Society, owing to his work with Boyle and Hooke, and contributions to experimental research at the society, e.g. his famous digestor, left from England to assist in the formation of a scientific academy in Venice.

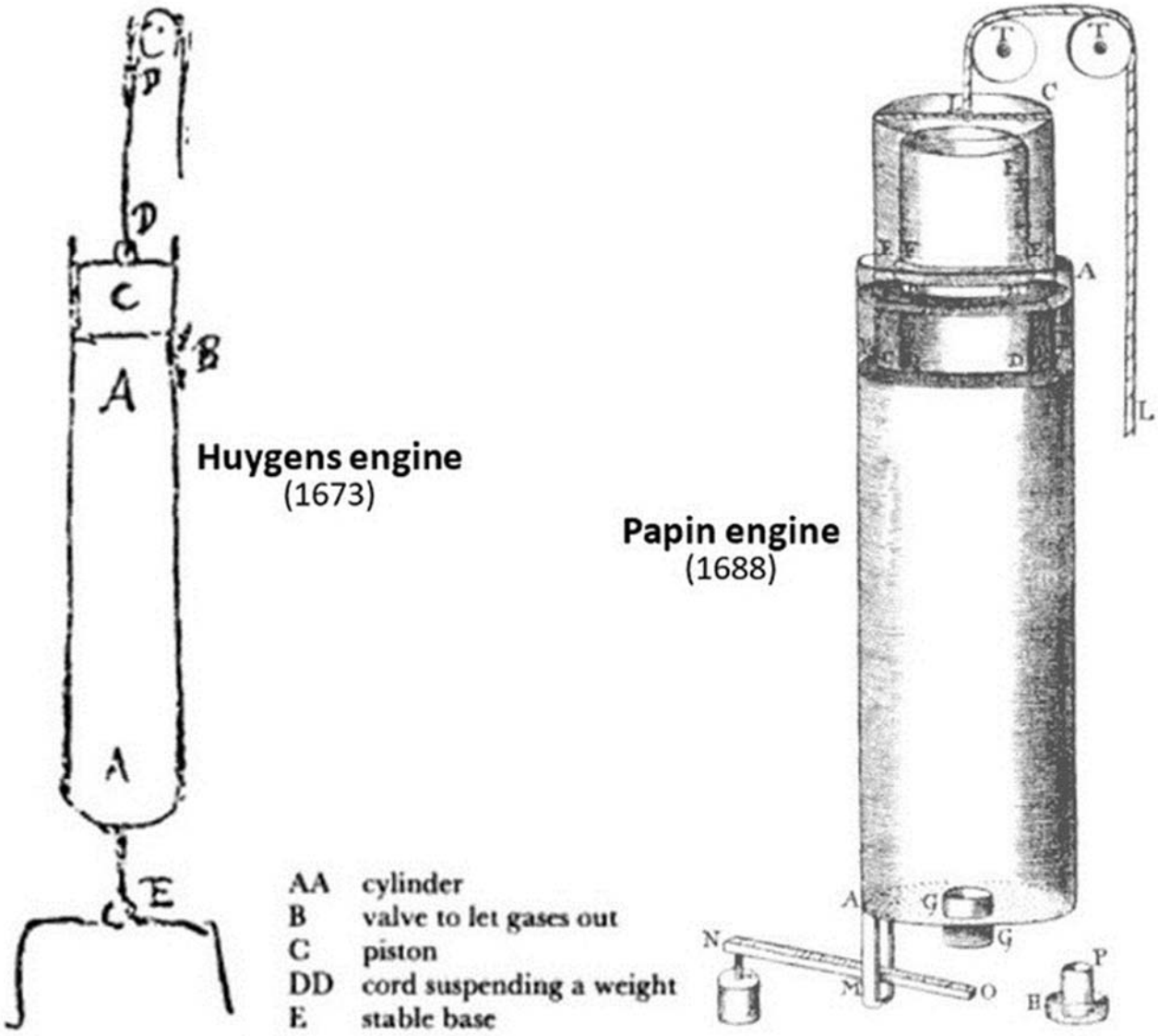
16.5 | **Papin Heat Engine** (1690)

In 1685, the Edict of Nantes was revoked, and all the Huguenots were expelled from France. Papin, being a Huguenot, traveled to Germany, whereat, from 1688 to 1695, he was associated with the University of Marburg. The following illustration shows Papin giving a demonstration, at the University of Marburg, Germany, of what seems to be Huygens-style gunpowder engine, able to 'lift a weight':[3]

During this period, specifically in 1685, Papin proposed a machine that would use the power of water from a river, as diagrammed below, from his published description (1688), that would turn a water wheel, which would turn a crank arm, that would work two suction pumps, that were connected to more suction like piston and cylinder devices below in the mine, which would turn a wheel, so to lift weight; these we might classify as struggling efforts, but important efforts, none the less:



In 1687 or 1688, Papin, then occupying a chair in Marburg, building on his previous gunpowder engine design work, such as his study of the Huygens gunpowder engine, below left, built an upgraded gunpowder engine, shown below right, where C is the attachment of the piston to the cord, D is the ventilator for the gases, F the edge of ventilator, HP the gunpowder holder, which fits to tube GG at the base of the cylinder, so that successive charges could be introduced, MNO is a safety valve lever weighted at N, LL is cord connected to a weight, and TT are pulleys:



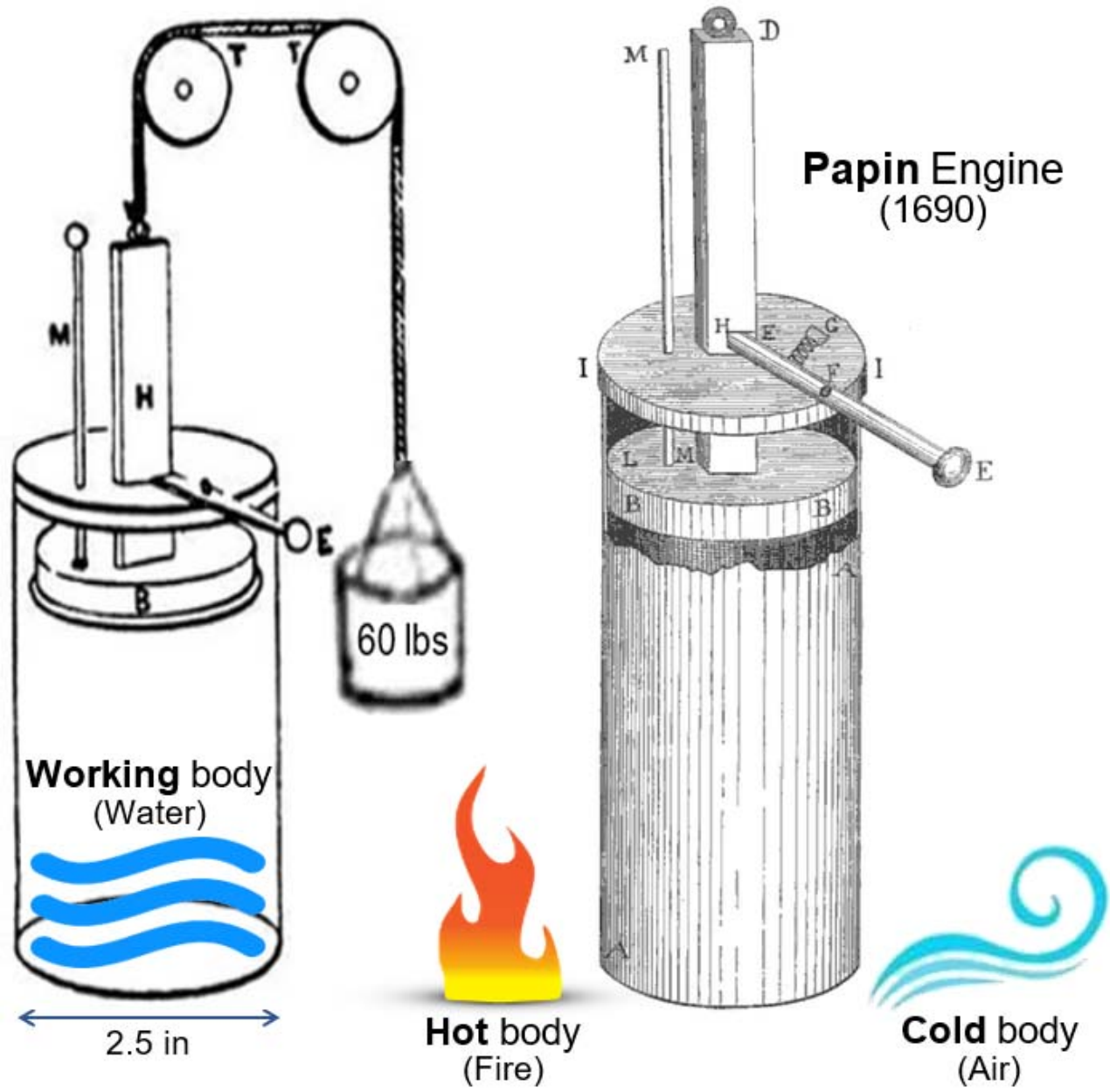
Here, Papin at this stage in his thinking, seems to have made a cross between Huygens' 1673 gunpowder engine and his 1680 steam digestor, a half breed, or crossover, so to say.

The chief difference in this new design, was that the piston was fitted with a "spring valve" that was closed by atmospheric pressure when the gases left, after which it was allows to make a powerful downstroke. One problem remained, namely: that a fifth or sixth part of the air and gases remained, leaving an imperfect vacuum (less powerful), similar to the issues Huygens faced with his engine.

In 1690, Papin, as described in his *A New Method to Obtain Very Great Motive Powers at Small Cost*, after letting this problem ruminate in his mind, two years later, he arrived at the solution of using water, heated and cooled, instead of gunpowder, ignited, to make a working engine able to lift things via heat; the following being his abstract of his idea:

> "Since it is a property of water that a small quantity of it, turned into vapour by heat, has an elastic force like that of air, but upon cold supervening is again resolved into water, so that no trace of the said elastic force remains, I readily concluded that machines could be constructed wherein water, by the help of no very intense heat, and at little cost, could produce that perfect vacuum which could by no means be obtained by the aid of gunpowder.."
>
> — Denis Papin (1690), *A New Method to Obtain Very Great Motive Powers at Small Cost* (pg. 137)

Shown below, we see the basic diagram of this engine which provides for a new method to obtain very great motive power from fire:



To operate this device, one first puts a few inches of *water*, the body of water defined, in the later 1865 thermodynamic terminology of Rudolf Clausius, as the so-called 'working body', into the volumetric space of the enclosed region confined by the adjustable piston B and cylinder A. One then pushes the piston down to the top layer of the water, letting the air escape through a small escape hole L, located in the piston head, which can be open and closed by rod M. When the piston is thus flush with the water surface, and all the air inside the piston and cylinder has escaped, the hole L is then closed using rod M.

In the second main step, one puts *fire*, called the 'hot body' in Clausius speak, to the outside of the cylinder. The water, accordingly, turns to steam and expands or pushes upward on the piston. When the piston reaches its top most position, a spring G pushes rod E into slot H, which thus holds the piston, and hence the system, in its place. Papin describes this step as follows:

> "A moderate fire being applied, the tube A, being made of thin metal, soon grows warm, and the water within it, being turned to steam, exerts a pressure so powerful as to overcome the **weight of the atmosphere** and force up the piston B, till the grove H of the handle D appears above the lid I, and the rod E is forced, with some noise, into the said groove by the spring G."
>
> — Denis Papin (1690), *A New Method to Obtain Very Great Motive Powers at Small Cost* (pg. 139)

In the third main step, the fire is moved away from the outside of the cylinder, or conversely the cylinder is moved away from the fire, which causes the steam to contact into contact with the colder air, outside the cylinder, which thereby resolves the steam back into water, making partial vacuum inside the volume of the piston and cylinder. Here, the air surrounding the piston and cylinder is 'cold' in respect to the steam, and is referred to as the 'cold body' in Clausius speak. It would not be, to note, until the development of the Savery engine, the followup to the Papin engine, built in 1696 to 1701, as will be discussed, that cold *water*, sprayed on the outer surface of the cylinder, instead of cold air, began to be employed as the cold body.

In the final step, of the Papin engine, one attaches some amount of weight, to be raised, placed inside of a bucket, which is connected to the piston rod H by a rope and pull arrangement. To raise the weight, one turns the anchor arm E, releasing the piston from its locked position, after which the piston descends, and the weight is raised, owing to the force of the atmosphere pressing down on the piston head, facing little opposition from partial vacuum within the piston and cylinder. Papin describes this step as follows:

> "Next, the rod E being turned round so far as to come out of the groove H, and allow the handle D to descend, the piston B is forthwith pressed down by the whole weight of the atmosphere, and causes the intended movement; which is of **an energy great** in proportion to the size of the tube."
>
> — Denis Papin (1690), *A New Method to Obtain Very Great Motive Powers at Small Cost* (pg. 139)

Papin stated, in his experiments, with this engine, that he used a 2.5-inch cylinder, or 'tube' as he called it, that was about two or three feet in height, which was able to raise 60-pounds, and that he had performed this operation 'alternately for a number of times', i.e. *cyclically* in modern thermodynamic speak.

This experimental demonstration, of fire employed to lift a weight, to bring things full circle, is the realization of the famous 1675 Robert Hooke proclamation that the 'vacuum made by fire lifts a weight', as he had penned fifteen years previous, in is secret new engine principle cypher. While Papin, as discussed, was at one point, Hooke's assistant, he was also Huygens' assistant and Boyle's assistant. No doubt Papin was influenced by the minds of all three.

These simplified truncated steps, as we will come to see, in this so-called 'one-stroke Papin engine' (1690), are the basics behind the operation of the Carnot engine (1824), the 'icon' of thermodynamics, so to say.

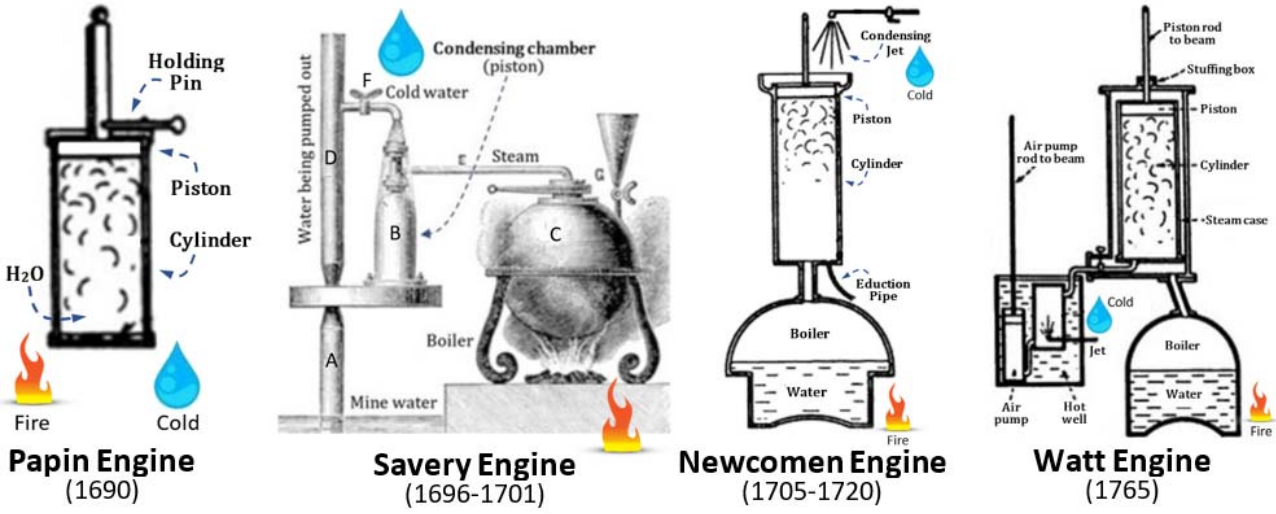
Now, although it may seem trivial, at this point, the jump from Papin (1690) to Carnot (1824), let alone Clausius (1865), was not so simple, as thermodynamics students, historically, have been obliviously taught. In the first place, to make the expansion phase, one has to 'move' a pile of fire or coal under the said piston, or alternatively move the cylinder into contact with fire. Next, to make the contraction phase, one has to 'move' the fire away from the piston and cylinder, or, alternatively, move the piston and cylinder away from the fire. In terms of the actual *engineering technology* that needed to be developed to make this movement process automated and realized, so that a more practical multiple-stroke engine could be made workable, the details to this are many, and would require the combined minds of Thomas Savery, Thomas Newcomen, and James Watt, in short, and at a minimum, to actualize this proposed Papin heat engine.

Jumping ahead a bit, as per *social systems* are concerned, we need not worry about these 'engineering technologies' required, at this point, although we will cover them shortly, we will note that owing to the daily rotation of the earth, 12-hours facing the sun (hot body), 12-hours facing the night sky (cold body), the surface of the earth, or rather its *systems* formed thereupon are so-called Papin engine working bodies:

The term ‘working body’, to clarify, does not become a term, until Clausius, but it is so dominate, that we will employ it here.

16.6 | Papin engine → Savery, Newcomen, and Watt

The ‘draft stage’ Papin engine, in print, over the next century, transformed into the working realization models of the Savery engine (1698), Newcomen engine (1705), and Watt engine (1765), as follows:



In 1824, as we will cover, Sadi Carnot, a French military engineer, unified or combined these four main designs, along with all other heat engine designs built in this period, and introduced the theoretical Carnot engine and Carnot heat cycle, which are to centerpieces and anchor points of thermodynamics.

One point that we will mentioned at this point, that is rarely discussed, is that in the original Papin design, the ‘system’ was a *closed* system, meaning that it was ‘closed’ to material flow across the boundary, but it could let heat in or out, and also let work in or out, via the moveable piston head, but more importantly, in terms of the conception of the *system*, all of the working body, i.e. the body of water/steam in this model, was contained within the volumetric region of the piston and cylinder, easy to see and conceptualized. When we begin to look at where exactly the ‘system’ is, in the Savery, Newcomen, and Watt engine, not to mention the various combustion engines, and other varieties of steam engines developed, in the period of Papin to Clausius, the actual *working body* or system, which in each of these cases is a body of water, moves around in the various parts of each respective engine, more difficult to follow and define where exactly the boundary is, and this system is not necessarily so ‘closed’ as in the simple Papin engine. Basically, in short, the system moves from the boiler to the receiver (or condenser); and in the Newcomen and Watt examples, cold water is actually added to the system, when the so-called ‘condensing jet’ is added or sprayed *inside* the piston and cylinder. Hence, we have mass, heat, and work, moving across the boundary of a system that is itself moving.

At this point, we have amassed the history of focused heat and vacuum engine theory germane to the inception of thermodynamics, which accrues, as we will cover shortly, via the minds of Carnot (1824), Clapeyron (1834), Thomson (1848), and Clausius (1865).

One point of so-called *gray area connectivity* that exists, at this point, to be frank about things, is the jump from Papin’s 1690 heat engine design, to the 1698 patenting of same basic engine, eight years later, by Thomas Savery, discussed in the next chapter, both of whom being connected to the Royal Society of England. Little is known about Savery, or the background his engine. Whatever may be the case, as we will attempt, shortly, to unfurl, Savery’s engine design was quickly modified by Thomas Newcomen, whose model, shortly thereafter, was made efficient by James Watt; all of which as pictured above.

We will attempt to attempt to patch together this historical disjunct in the following chapter. But, quickly, at the time of Savery’s patient, filed with the Royal Society, Papin was a Royal Society member, had performed experiments, e.g. with his digestor in front of the Royal Society, and many of his papers on vacuum and heat engines were read in front of the Royal Society. Moreover, Newcomen, who knew Papin

and his work, via Hooke, was a neighbor of Savery, by 15-miles. Some have conjectured that Newcomen, in fact had a working model of a steam engine, *before* Savery.

In short, by in large, in probability, Savery, read Papin's draft theory work on steam engines, and used this outline to make a working model. The overlap between the two is unmistakable: where as Papin says to put the water firs in contact with fire, Savery has a Boiler; whereas Papin says to put the steam in contact with a cold body, Savery has jet of cold water going over his 'condensing chamber' figure B. We will presume, herein, barring further years and decades of needed of historical research in this eight-year gray window of history, that Savery knew of Papin, and used his models, along with his own unique ideas, to make his Savery engine.

Synopsis: (add)

References

1. Boschiero, Luciano. (2009). "Translation, Experimentation and the Spring of the Air: Richard Waller's Essayes on Natural Experiments", *Notes and Records*, Royal Society, Oct 14.
2. (a) Boyle, Robert. (1680). *A Continuation of New Experiments Physico-mechanical, Touching the Spring and Weight of the Air, and Their Effects: Wherein are Contained Divers Experiments: Together with a Description of the Engines Wherein They Were Made. The Second Part* (Experimentorum novorum physico-mechanicorum continuatio secunda) (assistant writer: Denis Papin). English edition, 1682.
(b) Boyle, Robert. (1774). *The Works of the Honorable Robert Boyle, Volume Four* (editor: Thomas Birch) (§: A Continuation of New Experiments Physico-Mechanical, The Second Part (London, 1682) (author: Denis Papin), pgs. 96-159; §: Iconisme II: the Description of the Mercurial Gage, pgs. 100-102; §: Iconisme II: a Description of the Engine to Compress the Air, pgs. 102-; pressure vs force diagram, figure 2, pg. 101; images, pg. end matter) . A. Millar.
3. Figuier, Louis. (1868). *The Wonders of Science, or Popular Description of Modern Inventions: Steam Engine* (*Les merveilles de la science, ou Description populaire des inventions modernes: Machine a vapeur*) (Papin, 51+ pgs; Germany demonstration image, pg. 49; discussion, pg. 51). Publisher.
4.
5.

17. Savery

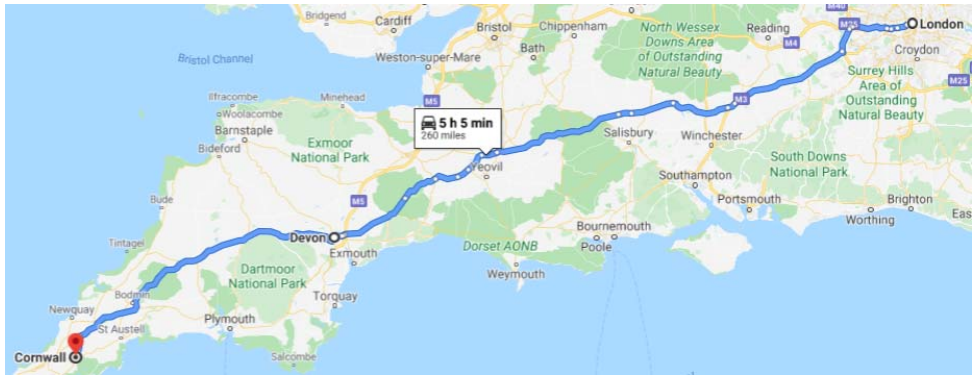
“.”

— Author (date), *Publication*

Chapter point: (add) [length: 6-pgs]

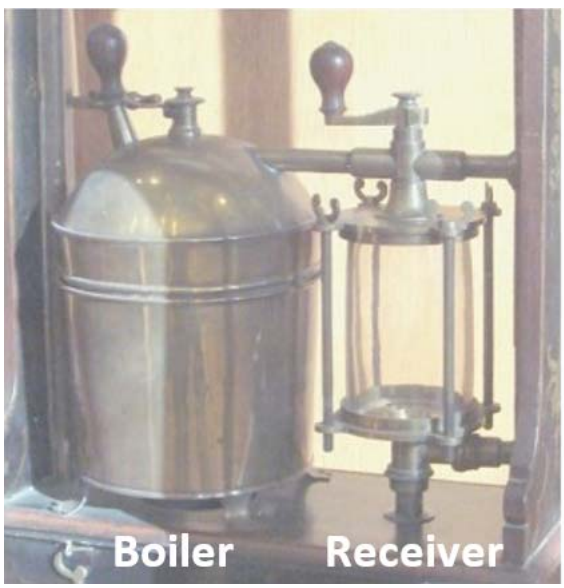
In 1696, Thomas Savery, age 46, an English military engineer, having been well-educated, stemming from prominent and wealthy family in Devon, England, had begun constructing some type of engine for the ‘raising of water by means of fire’ or ‘Miner’s friend’ as he later came to call it.

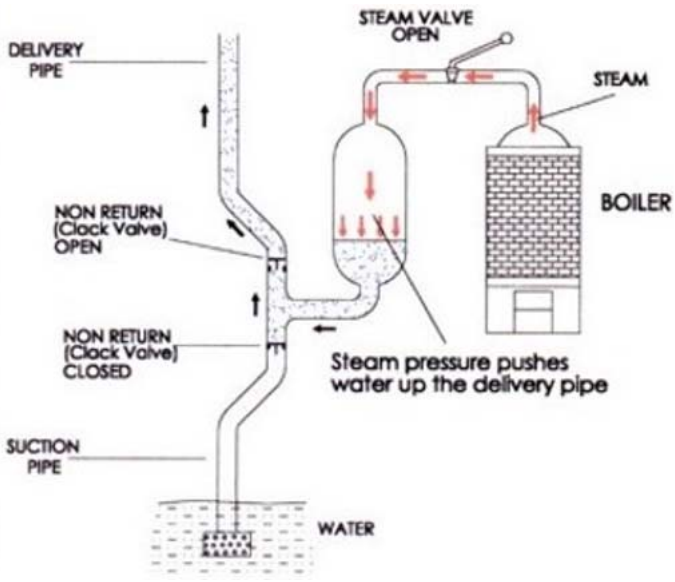
The location of Devon, England, as shown below, is affixed somewhat midway between London, home of the Royal Society, where Savery would eventually seek a patient for his device, and Cornwall, where the problem of the flooded mines was prominent, wherein miners, tempted to go deeper for richer ores, were being hampered by water floods, which had progressed to the point that they were carrying water out by a combination of human-carried buckets and horse-powered pumping devices, of the Ctesibius kind.[1]



Savery, prior to this, had been an inventor of sorts, e.g. making a clock for timekeeping, that the family used in their home or castle, and also building a human-powered paddle wheel boat, wherein men turned a capstan, or spindle, which turned the paddle wheels. Savery exhibited his paddle wheel boat or yacht, on the Thames, to the admiral of the English Navy, but it was turned down. After this, Savery turned his attention to the problem of flooded minds in Cornwall.

On 25 Jul 1698, Savery patented a design for a steam engine to be employed for pumping water out of mines. In 1699, Savery submitted a working model of his engine to the Royal Society, during which time successful experiments were made with it. On 14 Jun 1699, Savery demonstrated a small working model of his steam engine at Gresham College before an audience where it was approved of; supposedly, something akin to the following design:

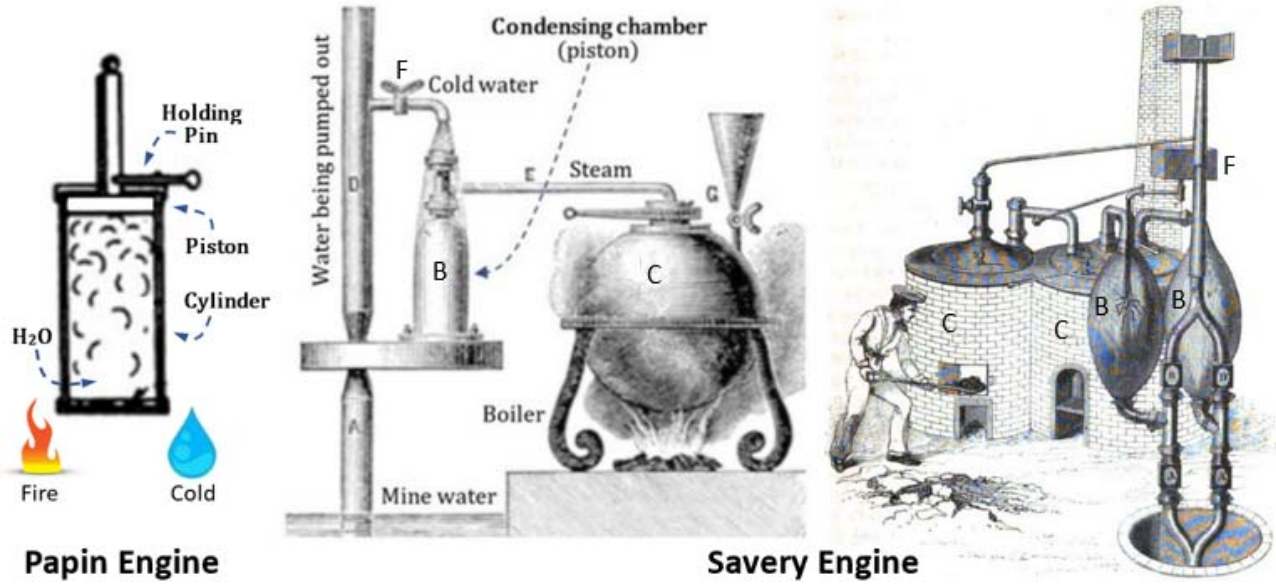




The basic operation of this engine, for 'raising water by means of fire' was that a man would fill the boiler with water, then light a fire below the boiler, then by means of two hand-operated valves, shown above left, would first let stem move from the boiler to the receiver. The receiver being connected, via a bottom pipe, to a lower reservoir of water, such as a tub of water, a river, or a flooded mine. The operator would then shut the boiler valve off. The receiver, having its own valve to the connecting reservoir of water, at this point shut off, is left to cool with the surrounding air of the atmosphere. Given time, eventually a vacuum thus forms, inside of the receiver.

Once the vacuum has formed, the operator turns the receiver valve, thus opening a connection between the receiver and the lower reservoir of water. Because, as Aristotle would say, nature 'abhors a vacuum', or correctly the weight of the atmosphere, pushes down the top surface of the lower reservoir, and forces water, from below, up past a non-return clack-valve, up into the empty space of the receiver. Once the formerly empty, or semi-evacuated, receiver is full of water, the operator opens the boiler or steam valve, which works to expel the water in the receiver, through a second one-way clack-valve, shown above right, upwards through the 'delivery pipe' or expulsion pipe. Savery's engine, at this point could only effect the raising of water by about 24-feet.

In a later model, Savery, to quicken the condensation part of his engine, began to spray cold water, i.e. the 'cold body' in Clausius speak, onto the outside of the condenser or condensing chamber B, as shown below (middle) or as a double condensing chamber below (right). Savery refers to pipe F as the *condensing pipe* and pipe D as the *forcing pipe*:



Papin Engine **Savery Engine**

These modified Savery engine (c.1700) variants, middle and right, basically, are a working realization of the Papin engine (1690), at left. There is, however, no extant connection, in this window of years, that Savery knew of Papin; we are only able to conjecture. The following gives us a general compass, as to point of invention:

> "**Before 1696** he had constructed several steam pumping engines to mines in Cornwall, and he described these as already working in his book entitled The Miners' Friend. He took with him a model to London and exhibited it to William III in 1698, and the King promoted Savery's application for a patent, which was secured in July, 1698, and an Act was passed confirming it in the ensuing year."
>
> — Sabine Gould (1908), *Devonshire Characters and Strange Events* (pg. 492)

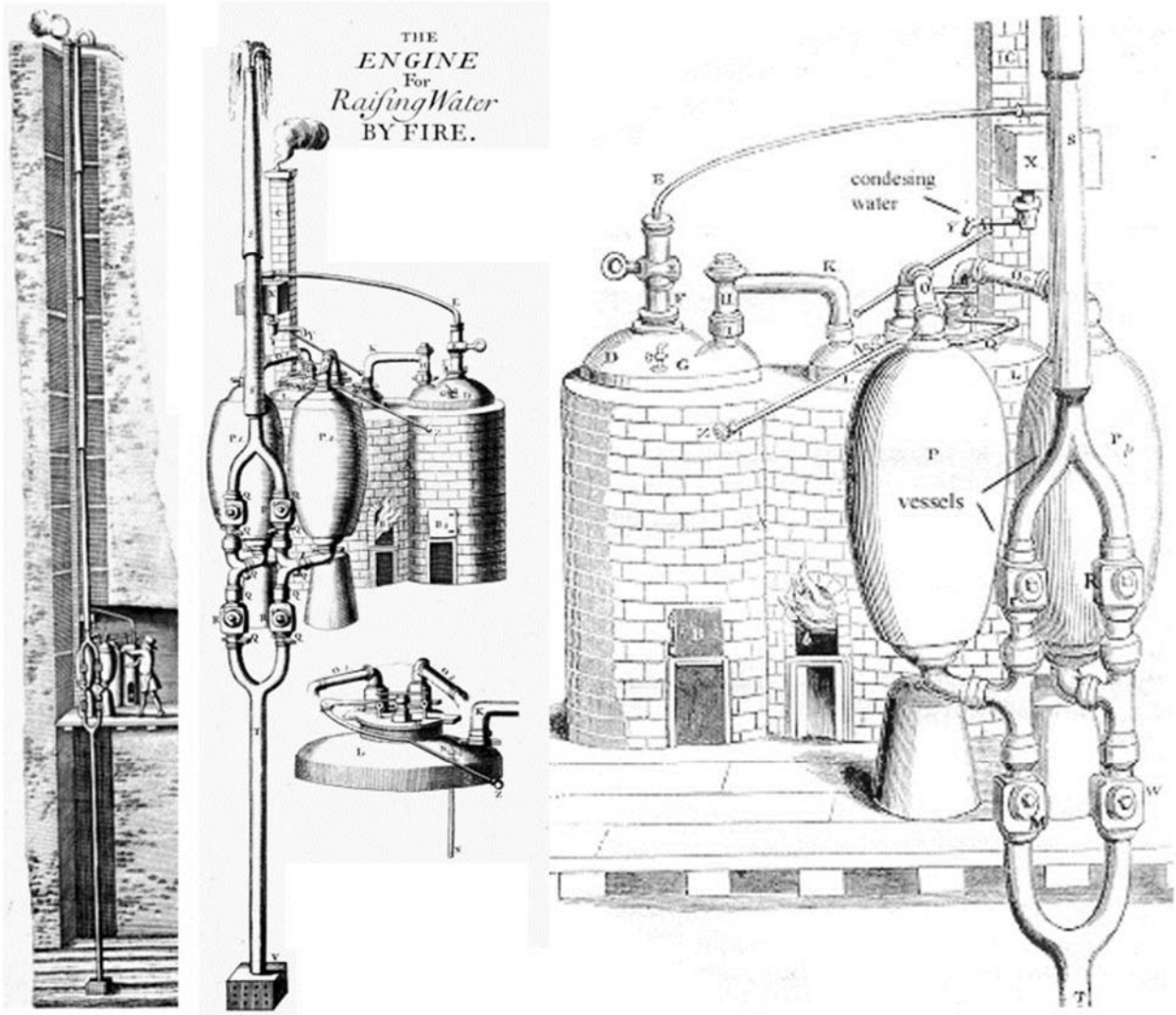
What has been reported, however, as to the origin of this 'Savery engine', comes from three anecdotal reports. Firstly, Stephen Switzer, in his *Introduction to a System of Hydrostatics and Hydraulics* (1719), who was said to have been 'intimate' with Savery, reported that the discovery came from a tabaco pipe, which Savery was smoking, who, to cool the pipe, plunged it into some cold water, and observed a stream of water to squirt out one of the ends of the pipe.

Secondly, are two reports by John Desaguliers, from his 1735 lectures on a *Course in Experimental Philosophy*, who says that in c.1705 he met Savery and observed one of his engines working, and who also

in 1728 build a Papin-modified Savery engine. The first anecdote, reported by Desaguliers, is that Savery was drinking a flask of wine in a Tavern, then, when it was almost finished, but the flask into the fire, for whatever reason, and then called for a basin of water, so to wash his hands; when the basin of water arrived, he plunged the flask, the contents of which being now in a steam state, into the basin of water, at which point the 'water of the basin was immediately driven up into the flask by the pressure of the air'.

The third anecdote, being the second report from Desaguliers, which he says he heard from a friend of Savery, was that someone had commented to Savery the suggestion or accusation that he had derived his engine from a reading of Edward Somerset's 1663 *A Century of Inventions*, penned in 1654, wherein Somerset reported, in very few words, how he had built some sort fire-based water raising device, which he had built into the side of his Castle, some marks of which exist to this day. Desaguliers, as he recounts things, says that Savery, upon hearing this accusation, firstly denied the conjecture, and afterwards went around all the bookstores in the area, and bought every copy of Somerset's book, and burned them.

In sum, either Savery invented his engine, via a smoking pipe, a wine flask, Somerset's book, Papin, independently, or by some other means. The following is a more detailed sketch of the Savery engine:



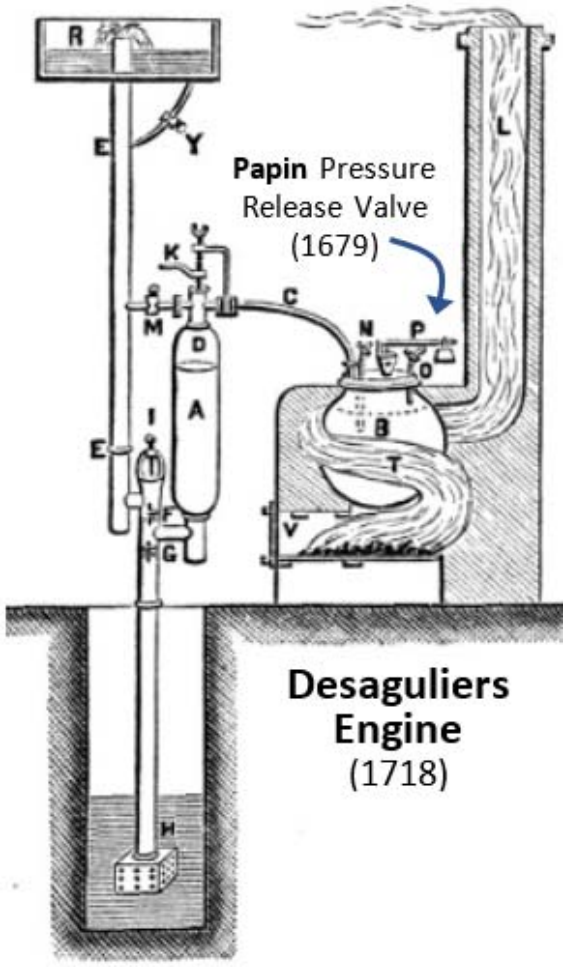
The reader is encouraged to go online to read the specifics of the operation of this engine.[4]

17.1 | Papin Connection?

Given the above, on one hand, we might readily concede that Savery was 'independent', as his published writing give us no indication, as to origin of idea. Possibly, Savery had no historical knowledge of attempted and or theoretical fire engine like devices before him, and either watched a wine flask in a fire or a tabaco pipe in water, and therein 'invented' the steam engine.

This presumed *independence*, in respect to Savery, as regards to Papin, who had published prior to him in the Royal Society, the same society that Savery patented the above engine, is equivalent to the supposition that Savery had never heard of Hero, which was the bulk thematical content of Somerset's book; Savery's round 'boiler', e.g., being nearly a duplicate of the Hero aeolipile design.

Retrospectively speaking, the period from 1690 to 1720, is a bit lacking in historical detail. What we do know, however, is that in c.1705 Hooke had suggested to Thomas Newcomen, the followup engineer to Savery, as we will discuss, to employ the piston and cylinder design of Papin, and also that in in 1718, John Desaguliers had made a Savery style engine, with the addition of Papin safety valve P, shown adjacent, as was introduced by Papin in his digestor.



To point out a few things, in regard to the Somerset, Papin, Savery, Newcomen, Hooke, Desaguliers connection, firstly, we will point out all of Papin's engine designs were *openly*-published for others to read about and work on, such as the German periodical *Acts of Erudite* (1688 and 1690); in the form of a book in French entitled *Collection of Various Pieces Touching Some New Machines*; and most importantly that summarizes of his engine models were read to the Royal Society in 1686 and 1687, which both Savery and Newcomen were connected with.

Secondly, Papin, from 1675 to 1679, was an experimental assistant of the Royal Society, working under Robert Boyle and Robert Hooke, and at one point was the curator of experiments of the Royal Society, as we have amply digressed upon. We also note that in 1682, some of the Royal Society's dinners were being cooked in Papin's digestor. Thirdly, although little discussed historically, we also know that Savery and Newcomen, who we will discuss in the next chapter, resided 15-miles from each other.

This so-called *unresolved* connection between Savery and Papin, is near, in the irritation level, to the yet *unresolved* connection between Guericke and Galileo; or Galileo and Beekman, for that matter. Either there was a direct connection, or these general ideas were just 'in the air', of this period, as they say, or we may have to pass on this issue and call it a 'paradigm change', as Thomas Kuhn refers to the dozen thinkers that, in his mind, independently, arrived at the *mechanical equivalent of heat*, which we have not yet digressed upon.

As we will see, as we progress through the history of chemical thermodynamics, there are several of these two-sided coins. Whatever the *flip* of these coins, it is repeatable experiment that decides things, in the long run. Hence, baring prolonged over-digression on this chapter, knowing that Papin published multiple summaries of his engine theory work, in multiple languages, in the years 1686 to 1690, we will let the following quotes summarize the general or predominate consensus in respect to the presumed jump from deeper work of Papin to the more trivial, albeit important, mechanical realization work of Savery:

> "I find it almost **impossible to believe that Newcomen never knew of Papin's** steam engine cylinder, at least by hearsay. Papin published sever other papers (3,4,5) and maybe there was someone at Dartmouth, one of the gentry perhaps, who could read French, if not Latin, and gave Newcomen access to Papin's work."
>
> — Joseph Needham (1987), *Science and Civilization in China, Volume Seven* (pg. 559)

> "The similarities between Newcomen's steam engine design and Papin's first piston-and-cylinder engine also suggest that **Newcomen might have seen Papin's articles** published by the Royal Society."
>
> — Anon (2012), *Engineers: From the Great Pyramids to the Pioneers of Space Travel* (§: Denis Papin, pgs. 106-107)

These conjectures aside, we will but note that, in Papin had come to learn about Savery, either by seeing his paddle wheel boat demonstration on the Thames, by seeing his steam engine exhibited at the Royal Society, by reading his 1702 *Miner's Friend* publications, or by word of mouth. However Papin learned of Savery, by 1707, Papin had built some sort of engine able to turn a paddle wheel on a boat; he wrote about this as follows:

> "It is important that my new construction of vessel should be put to the proof in a seaport like London, where there is depth enough to apply the new invention, which, by means of fire, will render one or two men capable of producing more effect than some hundreds of rowers."
>
> — Denis Papin (1707), 'Letter to Gottfried Leibniz', Jul 7

The boat Papin built and intended to send, from Germany to London, supposedly, was destroyed by some watermen who feared that this new invention might interfere with their trade.[1]

17.2 | Horsepower

In 1702, Papin, published a summary of his engine and its practical uses, in his *The Miner's Friend: or an Engine to Raise Water by Fire*, in which he gave the first outline of the concept of horsepower; the following is the main quote of interest:

> "Water, in its fall from any determinate height, has simply a force answerable and equal to the force that raises it. So that an engine which will raise as much water as two horses working together at one time in such a work can do, and for which there must be constantly kept ten or twelve horses for doing the same, then, I say, such an engine will do the work or labor of ten or twelve horses; and whereas this engine may be made large enough to do the work required in employing eight, ten, fifteen, or twenty horses to be constantly maintained and kept for doing such a work, it will be improper to stint or confine its uses and operation in respect of water-mills."
>
> — Thomas Savery (1702), *The Miner's Friend* (pg. 26)

In 1783, as we will discuss, the unit of 'horsepower' became standardized via the testing and measurements of James Watt and Matthew Boulton.

17.3 | Engine Difficulties

In the years following, Savery began to face several growing problems, the first of which being that his engine could only raise water to about 25-feet to 80-feet, depending on citation, and many of the Cornwell mines were flooded 300-feet deep. Therefore, if a mine owner wanted to employ Savery's engine, he would have to purchase several Savery engines, and install them at various levels, incrementally.

Second, when Savery tried to make is engine more powerful, so as to make one engine raise weight to a higher level, he began to find that the higher temperature and pressures needed to actuate this, would melt his rivets. Not to mention, the various explosions of his engines, that occurred. The high cost of fuel needed to operate several engines and the number of attendants needed to operate them, slowly grinded Savery's engine productions to a halt.

The adventurous reader is encouraged, before proceeding, to firstly, go online and read the Hmolpedia summarized article on the Savery engine, its variations over the years, and in particular the verbal details of its operation, so as to get some background in respect to the origin, in this particular engine, of the 'system', as modern thermodynamics defines things. Secondly, to go to the 'history of the steam engine' online article, and read at least several of the 18+ steam engine history books listed, Robert Thurston (1878), as a starting point.[2]

We will but mention, by name and summary, the following engine pioneers, as previously listed in the Hero engine pioneer table, that we have skipped over at this point: Gerolamo Cardano (1550), the inheritor of da Vinci's works, who is said to have 'devised a machine using the vacuum from condensed steam'; Lazarus Ercker (1574), who 'his *Sub-Terrarium Classroom* gives an illustration of metallurgists using aeolipile to produce a blast of steam in smelting ores'; Giovanni Porta (1601), who made an improved Hero fountain to shoot water upwards; Cornelis Drebbel (1609), who produced some type of solar-powered musical instrument; Salomon Caus (1615), who gave a summary of the historical devices employed to raise water by the aid of fire; Giovanni Branca (1629), who took a Hero aeolipile and made a steam turbine;

David Ramsay (1630), who, building on Caus, applied for a patent for a device to raise water from the Lowe Pitts by fire; John Wilkins (1648), who, in his *Mathematical Magic*, devoted a chapter to heat devices of Branca, Cardano, and Drebbel; Samuel Moreland (1661), who attempted to improve on Somerset's design, with limited success; Ferdinand Verbiest (1670), who made a Hero-Branca style turbine powered toy automobile; or Jean Hautefeuille (1678), who claimed to have invented a gunpowder engine independent of Huygens.[3] The reader is encouraged to go online to peruse these thinkers; as seemingly many of their idea contributions have influenced the inception of the steam engine, in subtle ways, not fully able to be understood or summarized no paper.

Synopsis: (add)

References

1. Gould, Sabine. (1908). *Devonshire Characters and Strange Events* (§: Savery and Newcomen, Inventors, pgs. 487-501) (WS). John Lane.
2. (a) http://www.eoht.info/page/Savery+engine
(b) http://www.eoht.info/page/History+of+the+steam+engine
3. http://www.eoht.info/page/engine+pioneers
4. http://www.eoht.info/page/Savery+engine
5.

18. Newcomen

> "Newcomen was as early in his invention as Savery was in his; only, the latter being nearer the court, had obtained the patent before the other knew it, on which account Newcomen was glad to come in as a partner to it."
>
> — Stephen Switzer (1729), *Introduction to Hydrostatics and Hydraulics* (pg. 342)

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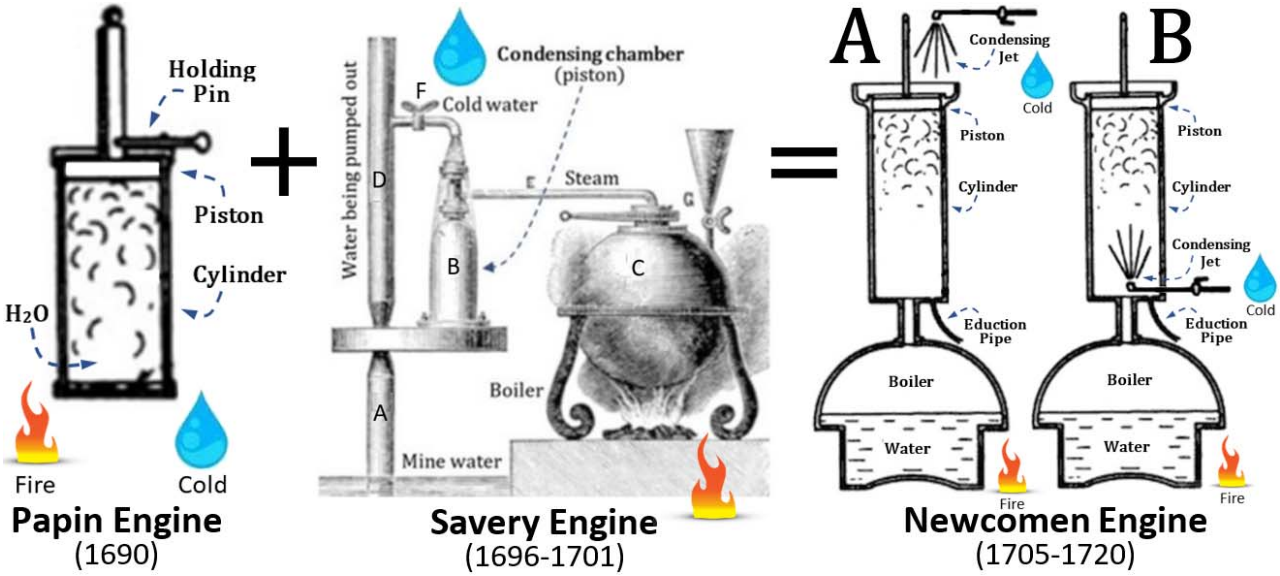
Next in line, following Thomas Savery, is Thomas Newcomen, who, being 14-years younger than the former, and coming from a wealth English family like Savery, and residing 15-miles from Savery, and having been said to have been working on his own engine to raise water by fire design, for three years in secret, is said to have arrived at a heat engine design 'as early as Savery', as reported by Stephen Switzer (1729), who knew both Savery and Newcomen.[1] There are some reports that Newcomen might have visited Savery. Whatever the details, Newcomen combined the ideas of Papin with those of Savery, as shown below, to make a more practical steam engine, which went through several design modifications over the course of its development:

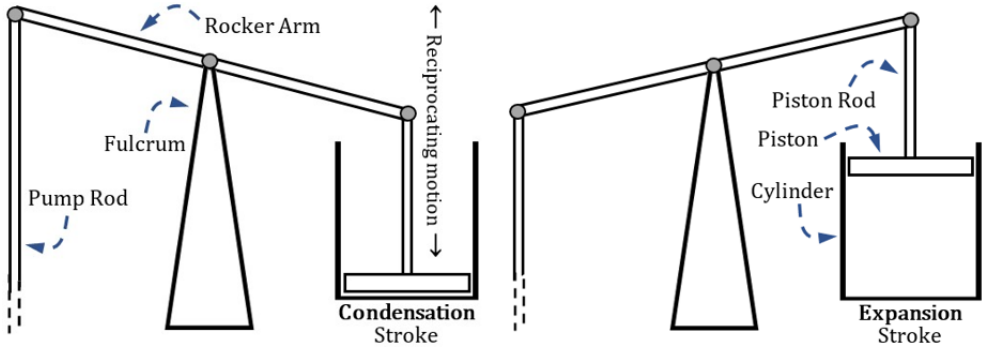


Firstly, Newcomen, having seen the insurmountable difficulties of the Savery design, plus having been directly knowledgeable about the Papin engine design, via his communications with Robert Hooke, took the piston and cylinder design of Papin, and the separate boiler and external condenser model of Savery, along with Savery's model of spraying the condensing chamber from above, such as shown in Newcomen model A, above right, and added to these a 'rocker-arm' that connected to the piston rod to a pump rod, that drew water out of a flooded mine.

18.1 | Rocker arm

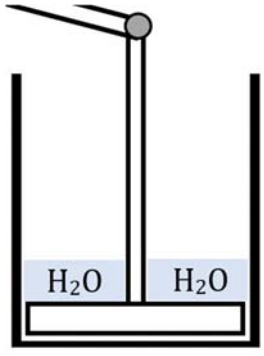
The first major change enacted by Newcomen, aside from the use of the piston and cylinder, was the introduction of the rocker arm. The rocker arm was in effect a large wooden seesaw, according to which as the piston went up, during the *expansion stroke*, when the steam valve was opened to the piston and cylinder, the pump rod went down. Then, during the *condensation stroke*, cold water was sprayed on the 'outside' of the piston and cylinder, as seen in Newcomen engine model A, which, as the cold body (cold water) was put in contact with the hot body (the steam inside the piston and cylinder), heat was thus withdrawn from the system to the surroundings, during which a partial vacuum was created in the volume of the piston and cylinder, after which the weight of the atmosphere would push down on the piston, forcing it to the bottom of the cylinder, i.e. work was done 'on the system' by the surroundings, in thermodynamic

speak, and hence the pump rod, at the other side of the rocker arm, was raised, bringing water, from the flooded mine, up with it as it rose. The basic operation of this rocker arm design is shown below:
:



Here, to note, in technical terms, we see the origin of the 'reciprocating motion', i.e. up-and-down or forward-and-back motion, engine. It would not be until James Watt that we are able to couple or transform reciprocating motion into 'rotative motion', which as a beg key to industrial revolution, most of whose machines needed a rotation mechanism to work.

18.2 | Internal spray cooling



The next modification made by Newcomen was the switch from spraying the cold water, during the condensation stroke, on the *outside* of the piston and cylinder, engine model A, to spraying the cold water directly *inside* of the piston and cylinder, so to cool the steam direct, without cool through the wall of the cylinder, before the steam could be cooled, thus speeding up the condensation phase, and hence increasing the number of strokes per minute. How this switch occurred is another anecdote of in the history of steam engine theory.

Specifically, in Newcomen model A, his original design, he put water above the piston, as diagrammed adjacent, so as to make a better air tight seal, similar to what Huygens, Boyle, and Guericke had done previously. Hence, one day, during the early trial or testing periods of the engine, they were watching the engine go as normal, say at a rate of about 5-strokes per minute, but then to their surprise, all of a sudden, they saw the engine make several rapid strokes. Confused about this, they took the engine apart, and found that the piston had a hole or was leaking along the side, and thus 'spraying' cold water into the piston. This gave Newcomen the idea to switch from outside spray cooling, to inside or internal spray cooling, as shown in Newcomen engine model B, above.

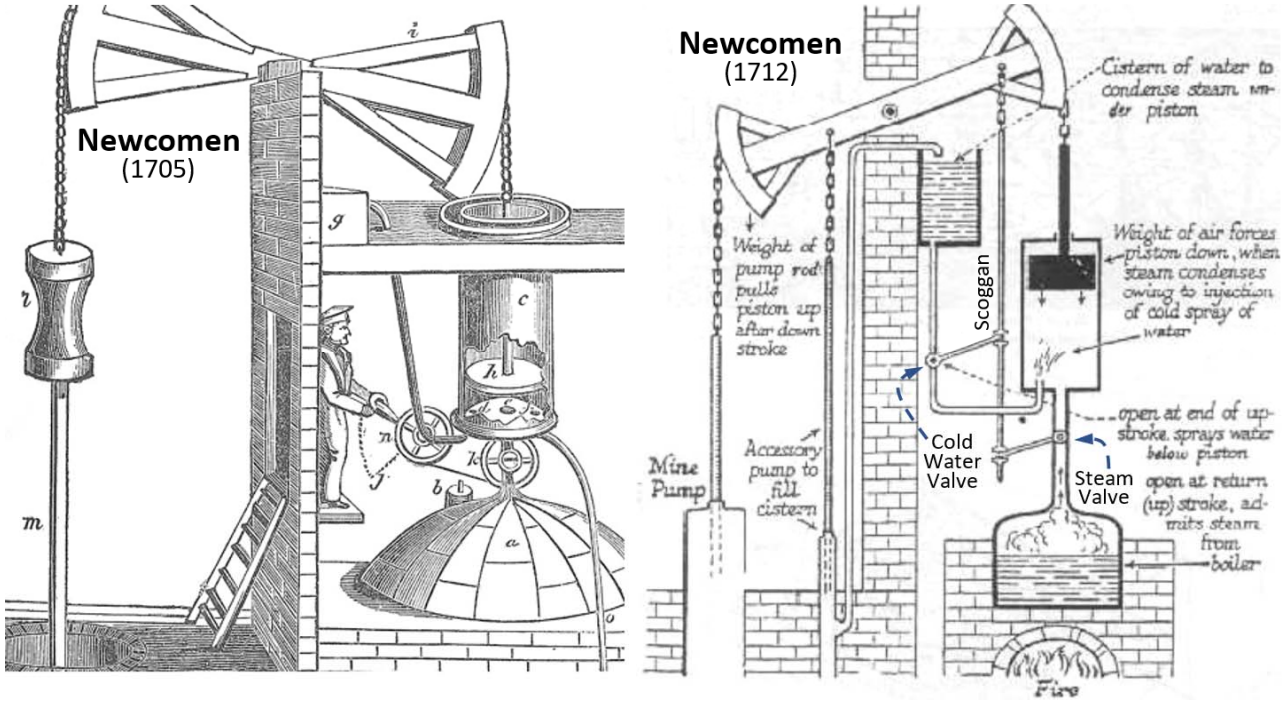
At this point, the thermodynamic 'system' model becomes a bit confused. The system is now 'open' to flow of matter, i.e. cold water, across its boundary. Carnot would later re-simplify all of this model, and all of the various models to follow, back to the basics of the Papin engine model, i.e. one 'closed' to the flow of matter across the boundary, in his famous Carnot cycle, which gets quite confusing, which we will learn about. This open system aspect of the Newcomen engine, simply, is a point to keep in mind.

To summarize we have seen two cycle types, the Papin engine cycle, where in a hot body and cold body are applied alternately to the piston and cylinder, thus making the piston rod go up and down, and now we have seen the Newcomen engine cycle, which is basically the same cycle, only the *cold body* (cold water spray) mixes with the *working body* (steam from boiler), and in both cases the *hot body* (fire) is but in contact with the working body, through metal wall of the cylinder in the Papin arrangement and through the metal wall of the boiler in the Newcomen design.

18.3 | Scoggan

The third major change introduced by Newcomen was the 'automation'. Specifically, in the Savery engine model, a worker had to stay of the engine constantly and work the two valves, one for the steam inlet, the other for the cold-water inlet, which had to be opened and closed alternatively. How this occurred is another anecdote.

Specifically, the origin of this automation invention, is attributed to a boy named Humphry Potter, who was assigned to work the two valves, such as shown above left. Potter, so the story goes, found this excessively tedious and monotonous work, and so invented a device he called a 'scoggan', wherein he took some rope, likely two pieces, tying one end of the rope to a location midway down the rocker arm, and the other end of each rope connected to each of the valves, one to the hot water valve, the other to the cold water valve, tied or timed in such a way, so that the work of turning the handles back and forth was done automatically. Eventually the rope was changed to metal rods, as shown below right:


Newcomen
(1705)
Newcomen
(1712)
Cistern of water to condense steam under piston
Weight of pump rod pulls piston up after down stroke
Scoggan
Weight of air forces piston down, when steam condenses owing to injection of cold spray of water
open at end of up-stroke, sprays water below piston
Cold Water Valve
Steam Valve
open at return (up) stroke, admits steam from boiler
Accessory pump to fill cistern
Mine Pump
Fire

The following is gist summary of Newcomen's general engine improvements, up to this point:[2]

> "Savery had created his vacuum by the condensation of steam in a closed vessel by dashing cold water against it. Papin had created his vacuum by exhausting the air in a cylinder, fitted with a piston, by means of an air pump. What Newcomen did was to **combine both systems**. Instead of employing Savery's closed vessel, he made use of Papin's cylinder fitted with a piston, but worked by the condensation of steam, still employing the clumsy system of dashing cold water against the cylinder."
>
> — Sabine Gould (1908), *Devonshire Characters and Strange Events* (pg. 497)

In 1712, Newcomen had erected an engine at Wolverhampton. Next, two engines were erected at Newcastle, a fourth was put up in Leeds in 1714. The fifth one was built in 1720 at Cornwall at Wheal Fortune, which had a four-foot diameter cylinder, making fifteen-strokes per minute, drawing up one hogsheads of water per stroke, from a depth of 180 feet; a 900 hogsheads of water per hour pumping capacity engine, in short.

Synopsis: (add)

References

1. Switzer, Stephen. (1729). *Introduction to a System of Hydrostatics and Hydraulics* (pg. 324). Publisher.
2. Gould, Sabine. (1908). *Devonshire Characters and Strange Events* (§: Savery and Newcomen, Inventors, pgs. 487-501) (WS). John Lane.
3.
4.

19. Watt

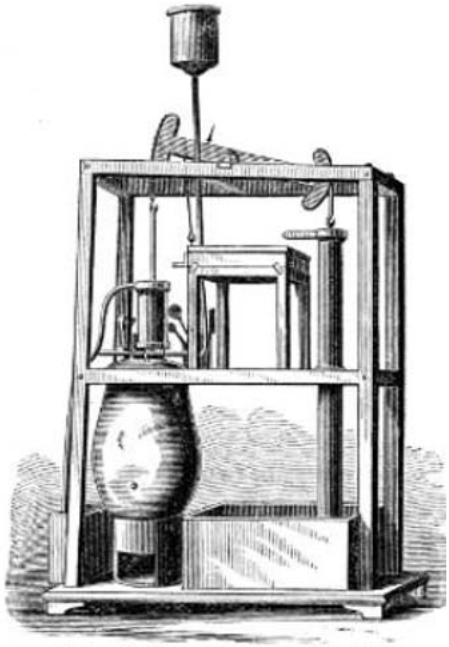
“.”
— Author (date), *Publication*

Chapter point: Digress on the improvements and additions James Watt made to the Newcomen engine, with heightened focus on his introduction of the *indicator diagram*, which became the Clapeyron pressure-volume diagram (1834), a graphical description of of the Carnot cycle (1824), which gave way to the three-dimensional so-called ‘graphical methods of thermodynamics’ of Willard Gibbs (1883) [length: #-pgs]

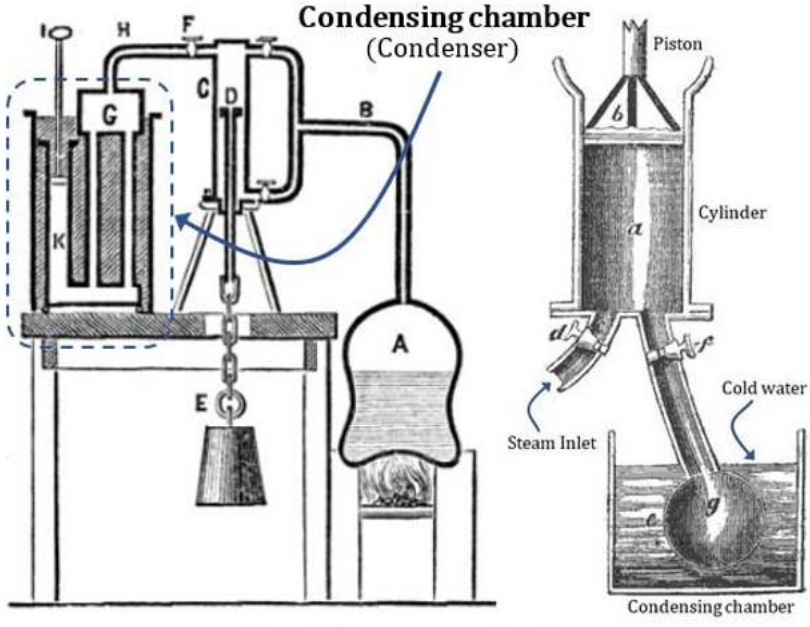
In 1763, James Watt, age 27, a Scottish student at the Glasgow University, whereat the chemist Joseph Black, the famous latent heat theory discoverer was a professor, was given the job to repair a small-scale classroom version of Newcomen engine, as shown below, left. Watt, in commentary on this Newcomen design, noted that the 1711 version of Newcomen’s engine had been able to replace a team of 500 horses, previously employed to power a wheel to pump out a mine, and that in the previous 50-years, few details had changed in respect to the basic design. Watt, from there forward, took it as his duty to actuate the needed ‘changes’, as he envisioned in his mind.

19.1 | Separate Condenser (1765)

In 1765, Watt built, below right, a first-draft laboratory sized version of his steam engine with a separate condenser, section G and K, where A is the boiler, C and D are the piston and cylinder. The ‘separate condenser’, consisted of two pipes of thin tin plate, 10 or 12 inches long and 1/6th of an inch in diameter, which was connected to K an air pump used as a ‘snifting valve’, the entirety of which being set in a cistern of cold water, the machine being able to lift an 18-pound weight E.



Watt’s Newcomen Engine
(1763)



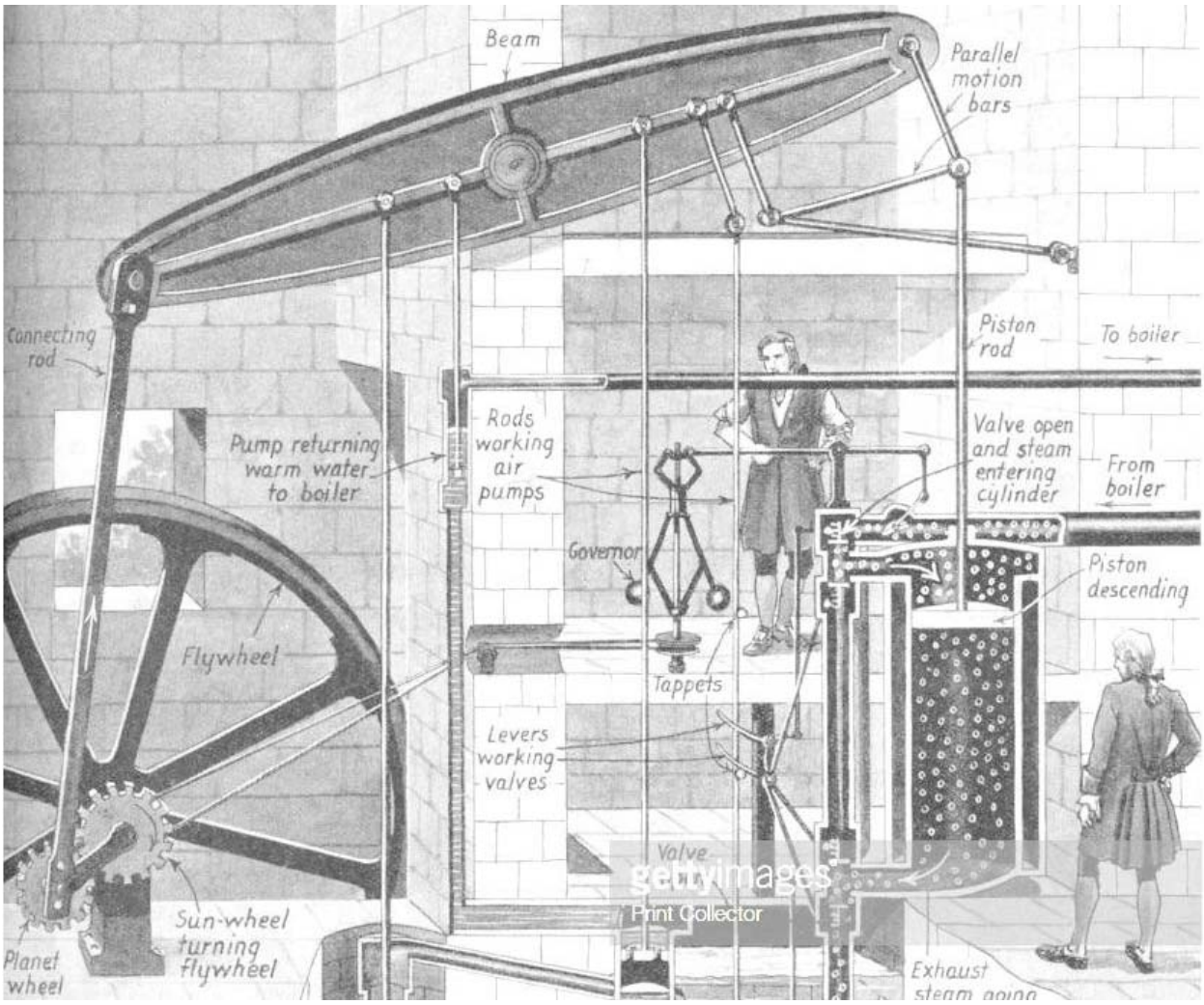
Watt’s Newcomen Engine
(1765)

The original separate condenser, basically, was employed in the Savery engine. What, however, states that he conceived of the separate condenser, per the visualization of the amount of wasted heat required to heat up and cool down the cylinder and piston, during each cycle, as seen in Newcomen engine version B. Whatever the case, at this point we have the piston and cylinder containing the ‘working body’, steam or water in this case, the ‘hot body’, namely the fire, and the ‘cold body’, namely the cold water that cools the

steam in the Watt condensing device. The Papin engine realized, in short. The Carnot engine, in basics, in preliminary historical context.

19.2 | Sun and Planet Gear (1781)

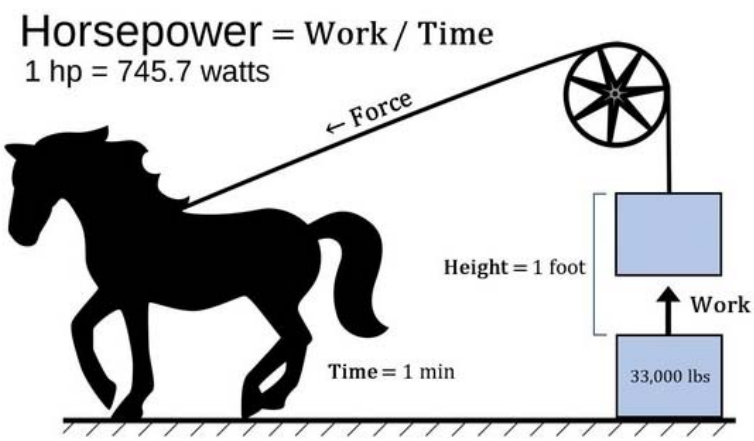
In 1781, Watt's investors wanted his engine to be able to actuate rotary motion, so to be applicable to factories, then currently operating via water wheels; the result was the invention of the sun and planet gear, shown below, left:

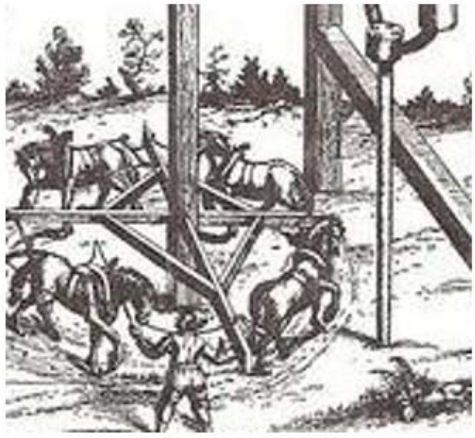


(add)

19.3 | Horsepower (1783)

In 1782, Watt found, via experiment, that a 'brewery horse' was able to produce 32,400 foot-pounds per minute, i.e. raise 32,400 pounds in one foot height in one minute:

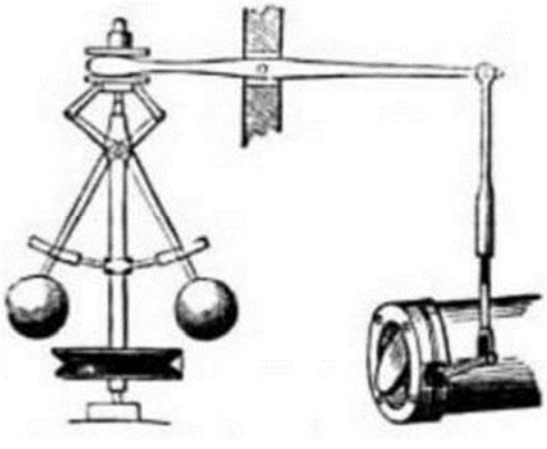


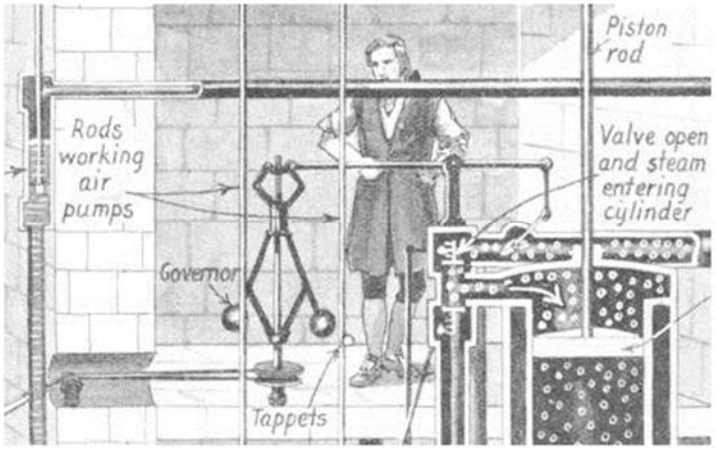


In 1783, Watt and his partner-assistant Matthew Boulton, working together, standardized the figure of one ‘horsepower’ at 33,000 foot-pounds per minute, in order to classify their engines for sale, and by 1809, this was generally accepted as equivalent of 1 horsepower, as it is today. This meaning that this was the amount of mechanical effect that the average ‘brewery horse’ could produce in one minute, aka 'mechanical equivalent of heat'. In other words, through experiment, it was determined that one horse, on average, could work a rotational device, such to turn gears, resulting in the lifting of 33,000 pounds of water out of a mine in one minute.

19.4 | Centrifugal Governor (1788)

In 1788, Watt invented the so-called ‘fly and ball wheel’ governor for controlling the steam throttle and thus the speed of his engine, by adapting the centrifugal or flyball governor from the flour mills, where it was used to regulate the ‘distance from the top millstone from the bed stone’, for use in his Watt engine; the gist of which is shown below:

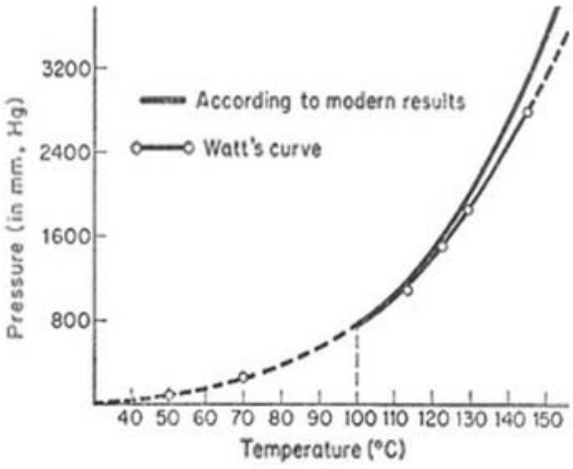


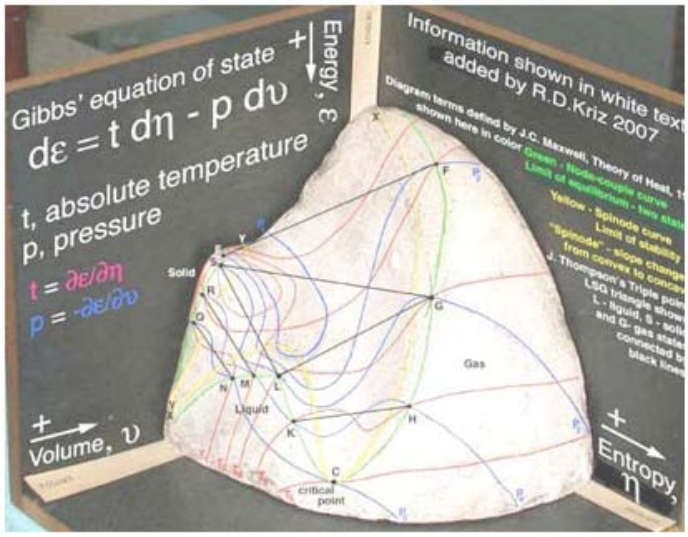


In this design, as the engine began to increase in speed, the two fly ‘balls’ would begin to rise in height, as they spun, owing to rotative force, balanced by the force of the weight of gravity pushing down on the balls. An optimal engine operation rate, could thus be set by the level of the eight of the two balls.

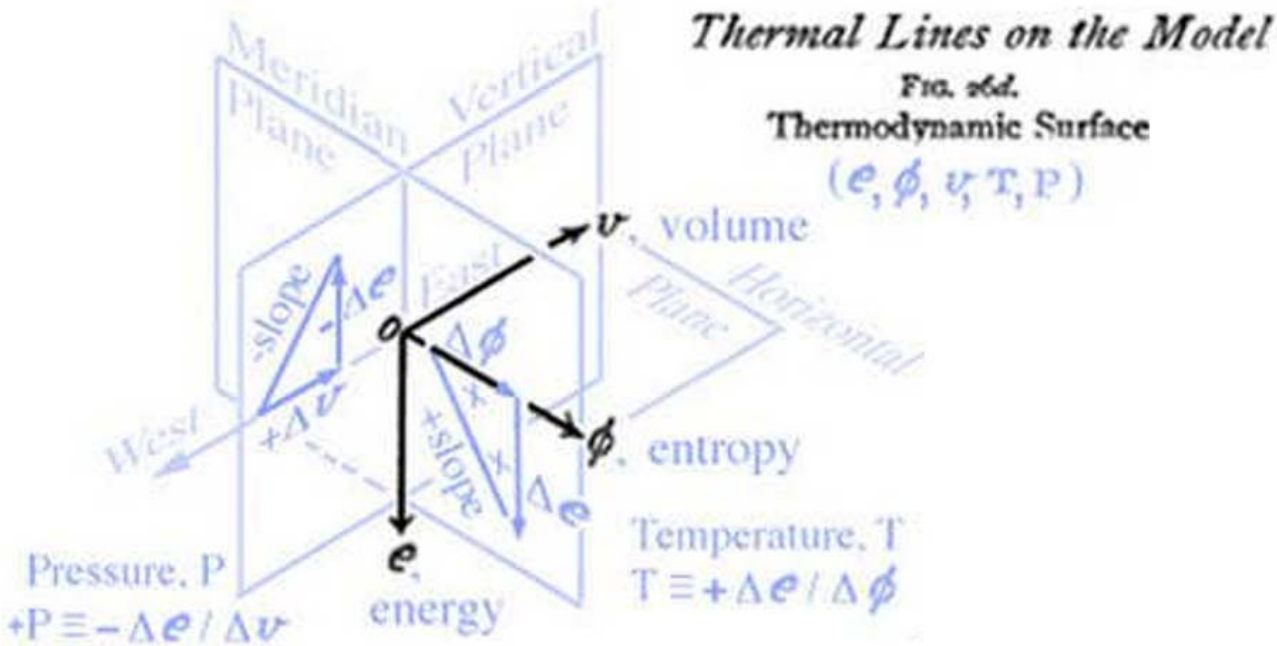
19.5 | Indicator Diagram (1796)

In 1764, Watt, puzzled by the breakdown in the so-called ‘law of mixtures’ in respect to calculating the efficiency of steam engines, based on four datum points, shown left, by circle dots, made the following pressure temperature graph or PT graph:





Here, in the calculative work of Watt, at least in respect to correlations of pressure and temperature in a steam engine, we are beginning to see some of the first roots of what would eventually become the highly complex subject of graphical thermodynamics or phase thermodynamics, wherein thermodynamic states of existence of phases, would become explained in terms of famous energy, volume, entropy, or USV graphs, showing a 3D representation of the state of the system, such as made by James Maxwell (1874) which he sent to Willard Gibbs as a gift. Each point on this 3D surface being a phase point. The goal, herein, will be to obtain a glimpse of the *state of our existence*, on the following graph:



Here, will recall the following famous statement by Henry Adams, who, after studying the science of graphical thermodynamics, had this vision:

> "On the physico-chemical law of development and dynamics, our society has reached what is called the critical point where it is near a new phase or equilibrium. I have run my head hard up against a form of mathematics that grinds my brains out. I flounder like a sculpin in the mud. It is called the 'law of phases', and was invented at Yale [by Gibbs]. **No one shall persuade me that I am not a phase**."
>
> — Henry Adams (1908/09), 'Letters to Charles Gaskell and Elizabeth Cameron'

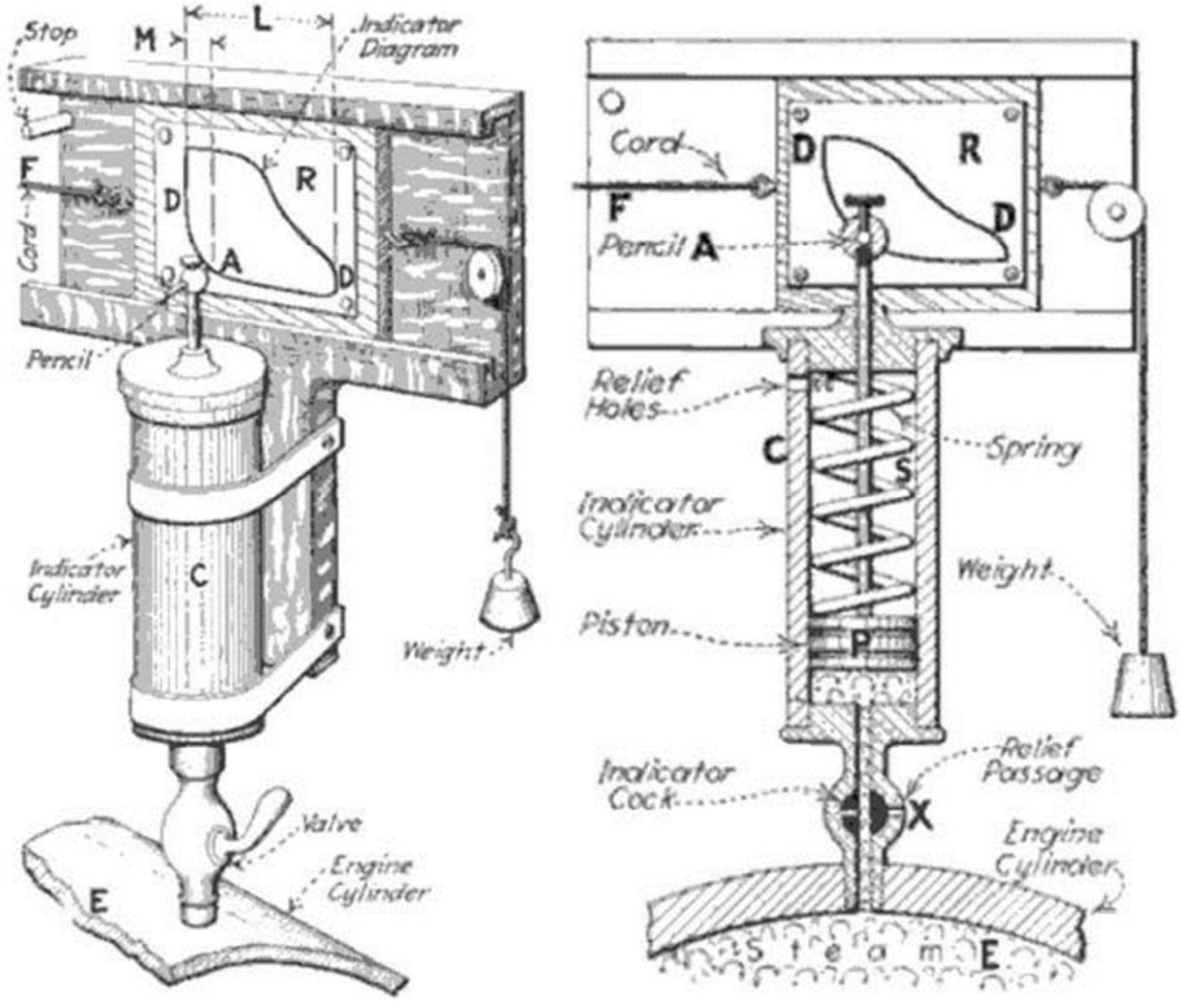
Who among us modern readers can convince themselves, so matter-of-factly, as Adams did, that they and or society is *phase point*, or location point on a Maxwell or Gibbs 3D USV graph? Here, we can only realize how backwards we are, intellectually?

In 1781, Jonathan Hornblower, a British engineer, invented a ‘compound steam engine’, which had two cylinders instead of one single acting cylinder. His engine design, however, was blocked by one or more of Watt’s patients. The matter went to court.

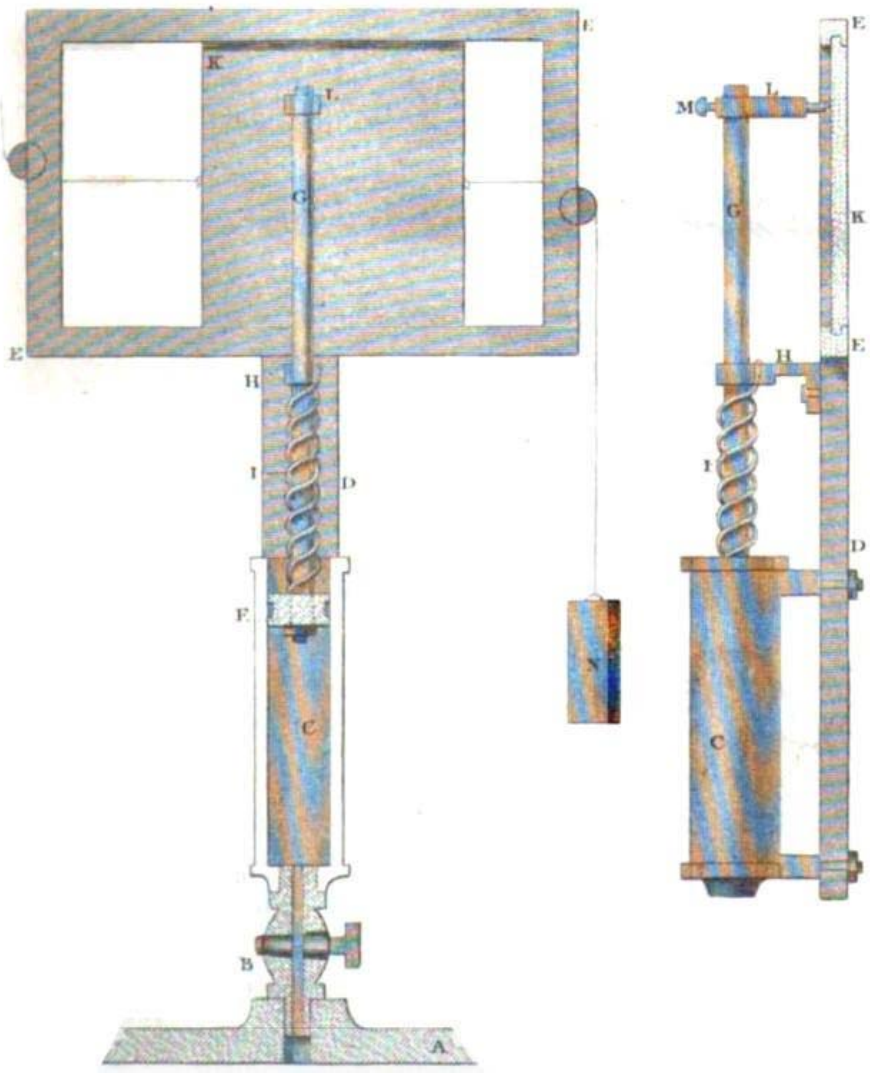
In 1792, Hornblower, in court, had employed the Davies Gilbert, an English mathematician, to prove, via the integral calculus methods, specifically, the method fluents and fluxions, invented by Isaac Newton in 1665, at the age of 22, in some way or another, that Hornblower’s engine was better than Watt’s engine, or something along these lines, and that it need patient exception; Watt reported the following on this court case to assistant John Southern:

> “They have brought Mr. Giddy [Gilbert], the high sheriff of Cornwall, and Oxford boy, to prove by fluxions, the superiority of their [Hornblower] engine, perhaps we shall be obliged to call upon you to come up Thursday to face his fluxions by common sense.”
>
> — James Watt (1792), ‘Letter to John Southern’, Apr 12

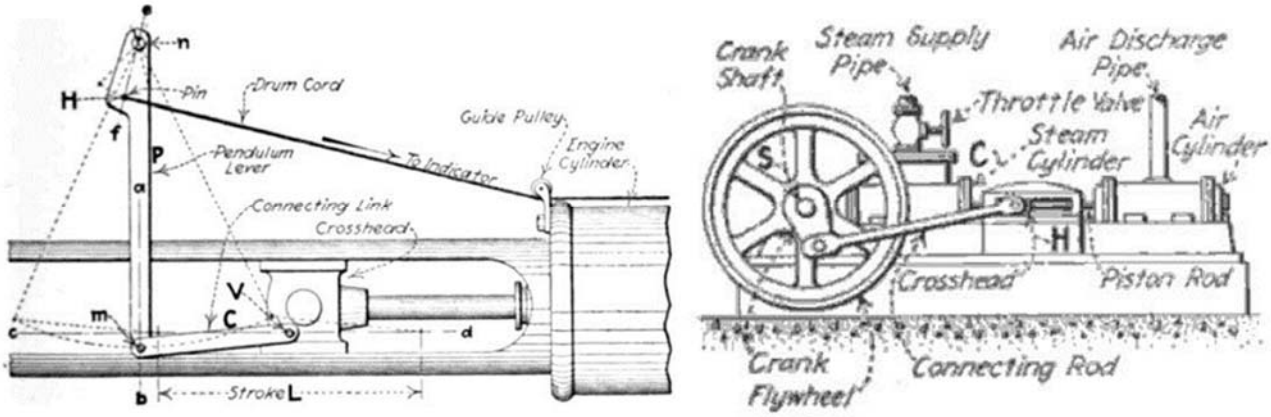
In 1796, John Southern, four years later, spurred on by this Gilbert boasting that Hornblower’s engine was superior, owing to his fluxions and fluents analysis of its operation, combined Watt’s previous pressure-volume graphical ideas, with Watt’s engine pressure gauge, and made a sideways-sliding volume gauge, which he attached to a board, with a sheet of paper on it, so to obtain a pressure-volume graph diagram of the engine, as shown blow:[1]



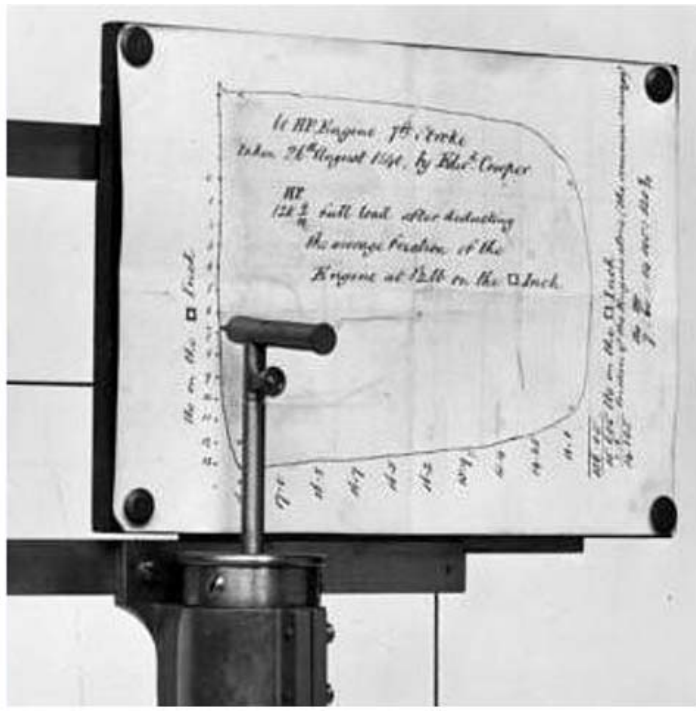
A more focused and detailed closeup depiction of this so-called Watt-Southern indicator diagram is shown below, according to which see that Watt our Southern is employing a spring to counterbalance the pressure of the steam, internal to the cylinder, so go gauge or give a scaled graphical representation of pressure on the vertical axis:



In respect to the how Watt and Southern gauged the volume of the system, on the horizontal axis, they affixed as so-called ‘reducing mechanism’, to the crosshead of the rod of the piston, comprised of a connecting, pendulum lever, pin, and a drum cord, which connected to indicator diagram board, moving it from side to side, proportional to the motion of the piston head, as shown below:[1]



The following are photos of what the actual indicator, i.e. pressure gauge and volume gauge, and indicator diagram, i.e. graph produced from the indicator, actually looked like, the left image from taken by the author while visiting the science museum in London:



The following is a synopsis of Watt's indicator diagram:

> "From manuscript (#) in the Royal Institution in Truro it is apparent that Gilbert had obtained a mathematical expression for the expansive power of steam that was formally similar to that of Daniel Bernoulli. This would, therefore, have been the first time it had been realized that in the case of an actual, expansively operated steam engine the work done (in this case Gilbert denotes this as the 'efficiency') is given by the area under the pressure/volume curve: in other words, the area under the indicator diagram. The modern symbol for this, of course, is: $\int PdV = W$. In fact, this involved integration [fluents] and not differentiation [fluxions], so Watt should have referred to 'fluents' rather than 'fluxions', but this is technical quibble."
>
> — Donald Cardwell (1971), *From Watt to Clausius* (pgs. 79-80)

One will have to refer back to these diagrams and models frequently, as no such working models exist currently, and as this is the origin of the Clapeyron pressure-volume diagrams, which were introduced in 1834 by Emile Clapeyron, to summarize what Sadi Carnot was saying in his 1824 discussions of the Carnot cycle. Combined, these diagrams, Watt, Carnot, and Clapeyron, become highly confused, for some peculiar reason, which is hard to pin down.

P

James Watt
(1736-1819)

19.6 | Unit of Power | W = J/s

Power: **P** or **hp**
Units: J/s
Date: 1783

In 1882, William Siemens, in his President's Address to the 52nd Congress of the British Association for the Advancement of Science, proposed that Watt might be an appropriate name for a unit of power; the proposing one watt defined as 'the power conveyed by a current of an ampere A through the difference of potential of a volt V', as shown below by the fourth equivalence:

$$1\,\mathrm{W} = 1\,\frac{\mathrm{J}}{\mathrm{s}} = 1\,\frac{\mathrm{N{\cdot}m}}{\mathrm{s}} = 1\,\frac{\mathrm{kg{\cdot}m^2}}{\mathrm{s^3}} = V \cdot A = \frac{V^2}{\Omega} = A^2 \cdot \Omega$$

In 1948, the watt as the unit of power was redefined using only length, mass, and time, wherein one watt was defined as the quantity of energy transferred in a unit of time, namely 1 J/s.[2]

Here, as in the case of the pascal as the unit of pressure, if one is desiring to quantify or theorize about social power, thermodynamically, the units one employs must be either one of the above variations of the

watt, or an equivalent derivative of the SI base units, such as quantifying human power in in terms of length, mass, and time. This becomes highly confusing, to say the least. Here, we have but stated the basics.

Synopsis: (add)

References

1. (a) http://www.eoht.info/page/indicator
(b) http://www.eoht.info/page/indicator+diagram
2. http://www.eoht.info/page/SI+unit+geniuses
3.
4.
5.

Chemical | Physical | Preliminary

In the following set of chapters, we will be covering needed prerequisite material in chemistry, e.g. the early models of thoughts on heat and combustion, and physics, e.g. the origin of the models of force, vis viva, and vis mortua, needed before one can begin to understand thermodynamics, firstly, and chemical thermodynamics, secondly.

20. Sulfur, Terra Pinguis, and Phlogiston

> "Geber and al-Razi taught a 'new theory' [**two principles**] in chemistry, the germ of which is contained in Aristotle's *Meteorology*, namely that metals are composed of mercury and sulfur, and are generated in the earth from these."
>
> — James Partington (1937), *Elements of Chemistry* (pg. 29)

Chapter point: (add) [length: 3-pgs]

In 300BC to 800AD, burning, generally, skipping some historical discussion, was considered as the passing off of the element 'fire', the third main element of Empedoclean four element theory, from its compounds:

In c.790, Arabian chemist Geber, amid his translation of Aristotle, and his summary and application of Empedocles' model of the *four elements* of things, namely: water, earth, fire, air, ordered according to Heliopolis creation myth order, to explain the variation with which different metals burn, by adding added *two principles*, namely 'sulfur', aka the stone that burns, as the new basis of combustibility, and 'mercury', being the vehicle of the ductility, fusibility and luster.

In c.900, al-Razi, the second main Arabian chemist, in his *The Secret of Secrets*, building on an earlier partial list made by Zosimos (c.300), along with ideas by Geber, divided mineral bodies into the following size classes:

1. Bodies | the metals
2. Spirits | **sulfur**, arsenic, **mercury**, and sal ammoniac
3. Stones | marcasite, magnesia, etc.
4. Vitriols | sulfate containing things, e.g. as known to Pliny
5. Boraces | borax, natron (soda), plant ash
6. Salts | common salt, kali (potash), salt of eggs, e.g. saltpeter, etc.

Later, someone, following Razi, introduced a third constituent principle or element, namely 'salt', representative of that which is permanent and unaltered by the action of heat, after which Geber's so-called *two principles* became a 'three principles' theory of the combustion.

In c.1430, Basil Valentine, a German alchemist, was teaching, as a matter of chemical fact, the doctrine of 'three elements', of sulfur, mercury, and salt, to explain the variations of combustion of metals, wherein 'sulfur' was the principle of combustibility, the more sulfur something contained, the more it would combust; 'mercury', which explained the fluidity of metals, and 'salt' which was used to explain the solidity of things, not effected by heat.[2]

In c.1535, Paracelsus promulgated the three elements doctrine so vigorously, that this doctrine became associated with his name; the gist of which, as concerns the development of thermodynamics, was that he was advocating the following axiom, in respect to all things that burn or combust:

> "All that burns is sulfur."
>
> — Geber (c.1535), *Publication* (pg. #)

In more detail, in respect to what Geber considered to be the seven metals:

> "Know that all the seven metals are brought forth after this manner, out of a threefold manner, namely: **mercury, sulfur, and salt**, yet in distinct and peculiar colors. Now this is not to be

understood so that of every mercury, every sulfur, or of every salt, the seven metals may be generated. Concerning the generation of minerals, and half metals, nothing else need be known than what at first said concerning metals, namely that they are in like manner produced of the three principles: mercury, sulfur, and salt, and yet with their distinct colors. The generation of gems is from the subtlety of the earth of transparent and crystalline mercury, sulfur and salt, even according to their distinct colors. But the generation of common stones is of the subtlety of water, of mucilaginous mercury, sulfur, and salt."

— Geber (1537), *Of the Nature of Things* (pg. #)

The model of *four elements* of all things, combined with the three principles model of combustion, became, shown below, the de facto standard model of chemistry, for the next two-centuries:

In respect to how combustion worked, in this three principles scheme of things, starting with the Paracelsus model (1537), below left, substituting wood for metal, knowing that the three principles model of combustion eventually began to be applied universally to all kinds of combustion, when a thing, such as a log of wood or some metal burned, according to Paracelsus, the sulfur would represent the flame or heat of the fire, the salt the solidity of the wood or metal, not affected by the fire, and the mercury would be the smoke leaving the process, in short, give or take a few details left out:

In 1699, Johann Becher, a German physician and chemist, upgraded Paracelsus' sulfur model of combustion into his so-called fatty earth or *terra pinguis* model of combustion, the gist of which being that when something burns or combusts, terra pinguis leaves the body, and ash is left behind, as shown above middle; Becher elaborates on this model as follows:

"Concerning the second principle of minerals, which is fatty earth, aka 'terra pinguis', improperly called sulfur, we find the three earths in animals, vegetables, and minerals. These three have a great affinity one for the other, and a great analogy. While *terra pinguis* is related to the other earth which we have already treated and whence metals and stones obtain their liquidity and fusibility, it most certainly has a great relationship and analogy with the earth of vegetables, that, namely, which is present in the calcination of vegetables and the lixiviation of ashes. It can also be prepared from all vegetables, for this earth, although it seems to be useless and of no value, has a very great analogy with the preceding earth of minerals and magnetism. This is apparent in the glassmaker's art, for when the glassmaker makes glass out of stone and flint, that is, from the aforementioned earth of minerals, which is thickened in flowing, either because of a lack of salt, or because of an excess of fire, so that it is again made hard and coagulates, nevertheless as soon as the preceding earth is injected from the ashes, not only is the whole mass of glass made more flowing, but also takes on growth and augment. This not only proves the great affinity of vegetable earth with mineral, but even a great likeness, harmony, and analogy, since this earth per se can be made into glass."

— Johann Becher (1669), *Subterranean Physics* (pgs. 129-32)

In 1703, George Stahl, Becher's student, modified his mentor's terra pinguis model of combustion into a so-called 'phlogiston model' of combustion, according to which *heat*, no longer thought of as terra pinguis or sulfur, was a fire-like element, having mass, called 'phlogiston', contained within all combustible bodies and released during combustion, as pictured above right.

At this point, in the history of science, we are beginning to see a semi-quantitative model of heat, as some sort of particle with mass. While not entirely correct, as in many cases, one has to take one or two steps forwards, before one can take several steps backwards.

> "It is difficult, in our endeavors to discover the principles of a *new science*, to avoid beginning the guesswork; and it is rarely possible to arrive at perfection from the first setting out."
>
> — Antonine Lavoisier (1789), *Elements of Chemistry* (pg. 108)

This Stahl phlogiston model of heat, held-sway for the next eight centuries.

To exemplify, in 1774, when Joseph Priestley discovered oxygen O_2, which had the remarkable property that it supported combustion far better than normal air (N_2 and O_2), Priestley named this new gas 'de-phlogist-icated air', because he thought that this new gas (O_2) acted as a receptacle or holder for Stahl's phlogiston, or the matter of heat, such that when say wood or metal reacted or combusted with oxygen, that the oxygen would absorb the phlogiston from the wood or metal.[1]

In 1775, when Antoine Lavoisier, the curator of the new term 'caloric', which we will soon become overly-familiar with, began to investigate Priestley's new gas, and had already harbored doubts about the existence of phlogiston.

Synopsis: (add)

References

1. Lavoisier, Antoine; Laplace, Pierre. (1783). *Memoire on Heat* (Memoire sur la Chaleur) (translator and introduction: Henri Guerlac) (§: Introduction, pgs. vii-xviii; dephlogisticated air, pgs. vii-viii). Academic Press, 1982.
2. http://www.eoht.info/page/Three+principles
3. http://www.eoht.info/page/Entropy+models
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21. Title

“.”
— Author (date), *Publication*

Chapter point: (add) [length: #-pgs]

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Text

21.1 | Galileo's *Momento* (1592)

Text

21.2 | Descartes' Momentum (c.1640) | mv

Text

21.3 | Huygens' Conserved Collisions (1669) | mv^{-2}

Text

21.4 | Lagrange's half factor (1788) | $T = ½ mv^2$

Text

21.5 | Vis viva as Heat

Text

21.6 | Actual Energy (Rankine, 1853) → *Kinetic Energy* (Thomson, 1862)

Text

Synopsis: (add)

References

1. Lavoisier, Antoine; Laplace, Pierre. (1783). *Memoire on Heat* (Memoire sur la Chaleur) (translator and introduction: Henri Guerlac) (§: Introduction, pgs. vii-xviii; dephlogisticated air, pgs. vii-viii). Academic Press, 1982.
2.
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Further reading

● Hanlon, Robert. (2020). *Block by Block: the Historical and Theoretical Foundations of Thermodynamics* (Illustrators: Robert Hanlon and Carly Sanker) (§10: Rise of mv^2, pgs. 169-79). Oxford University Press.

22. Vis Mortua

“.”
— Author (date), *Publication*

Chapter point: (add) [length: #-pgs]

Sentence.
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Text

22.1 | Galileo’s *Peso Morto* (1638)

Text

22.2 | Leibniz (1673)

Text

22.3 | Latent Energy → *Potential Energy* (1853)

Text

Synopsis: (add)

References

1. Lavoisier, Antoine; Laplace, Pierre. (1783). *Memoire on Heat* (Memoire sur la Chaleur) (translator and introduction: Henri Guerlac) (§: Introduction, pgs. vii-xviii; dephlogisticated air, pgs. vii-viii). Academic Press, 1982.
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23. Lagrange

> “.”
>
> — Author (date), *Publication*

Chapter point: (add) [length: #-pgs]

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24. Newton

“.”
— Author (date), *Publication*

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21.1 | Mass vs Weight

In 1609, Johannes Kepler, began to allude to a proto-distinction between ‘mass’, symbol *m*, above, from weight, symbol *mg*, as follows:

> “If two stones were removed to any part of the world, near each other but outside the field of force of a third related body, then the two stones, like two magnetic bodies, would come together at some intermediate place, each approaching the other through a distance proportional to the mass [moles] of the other.”
> — Johannes Kepler (1609), *Astronomia Nova* (pg. #)

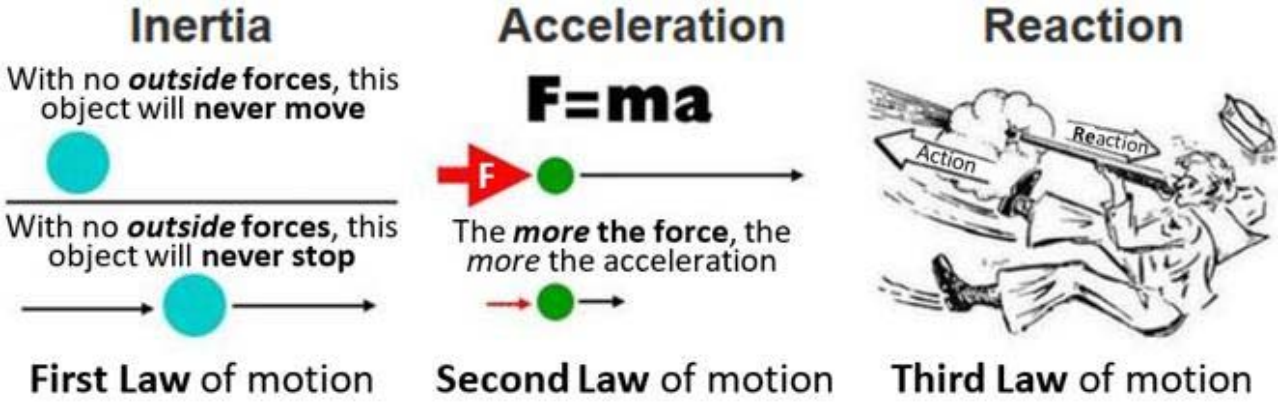
In 1673, Christiaan Huygens progressed further on this as follows:

> “When particles move with equal speeds along equal circles, the centripetal forces are to each other as the ‘weights of the particles’ or as their ‘solid quantity’ indicates mass.”
> — Christiaan Huygens (1673), *De vi Centrifuga* (pg. #)

d:

22.2 | Laws of Motion

In



d:

Near the surface of the earth, the work *W* done in lifting an object of mass *m* through a height *h* is equal to the product of these times the acceleration of gravity *g*, defined as follows:

$$W = mgh$$

with substitution of Newton's second law of motion:

$$F = ma$$

where the acceleration 'a' is g or 9.8 m/s^2, for bodies accelerating toward the earth, we find that work *W* can also be defined as the force *F* moving the mass times the distance *d* through which the body moves:

$$W = Fd$$

This formulation, however, was not derived until Gustave Coriolis in 1829, as we will discuss, referring to this formula as the *principle of the transmission of work*, on the core formulations in thermodynamics.

21.3 | Unit of Force | **N = kg·m/s²**

Text

21.4 | Query 31

Text

Synopsis: (add)

References

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25. Affinity Chemistry

“.”
— Author (date), *Publication*

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22.1 | Geoffroy Affinity Table

Text

22.2 | Cullen Affinity Reaction Diagram (1757)

Text

22.3 | Bergman Affinity Table (1775)

Text

22.4 | Goethe Affinity Table (1796)

Text
d:

Chemical species | Human
Thims | 1995
SUBSTANCE FORMULA ΔG_f° (kJ/mol)
Liam (m) CH_3COOH −389.45
Emma (f) CH_3CHO −139.08
Noah (m) CH_3COCH_3 −153.55
Olivia (f) C_2H_2 209.2
Sophia (f) C_6H_6 124.5
Mason (m) C_2H_5OH −174.18
Ethan (o) C_2H_6 −32.89
Logan (m) C_2H_4 68.1
Isabella (f) $HCOOH$ −346.0
Lucas (m) $C_6H_{12}O_6$ −910.56
Mia (f) CH_4 −50.8
Charlotte (f) CH_3OH −166.3
Oliver (m) $C_{12}H_{22}O_{11}$ −1544.3

This table is from the ‘soul mate’ article.

Synopsis: (add)

References

1.
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26. Lavoisier

“.”
— Author (date), *Publication*

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Text

d:

“If heat is a fluid, it is possible that during the combination of various substances, it combines with them or is evolved from them. Thus, nothing indicates a priori that the ‘free heat’ is the same before and after the combination; nothing, moreover, suggests in the hypothesis that heat is only the vis viva [kinetic energy] of the particles of bodies, for **in substances that combine together, acting on one another by virtue of their mutual affinities, their particles are subjected to the action of attractive forces that can alter the amount of their vis viva, and, subsequently, the amount of heat**. But one should accept the following principals being common to the two hypotheses:

> ‘If, in any combination or change of state, there is a decrease in free heat, this heat will reappear completely whenever the substances return to their original state; and conversely, if in the combination or in the change of state there is an increase in free heat, this new heat will disappear on the return of the substances to their original state.’

This principle, moreover, is confirmed by experiment, and in what follows the detonation of saltpeter will furnish us with visible proof. We can generalize it further, and extend it to **all the phenomena of heat**, in the following way:

> ‘All changes in heat, whether real or apparent, suffered by a system of bodies during a change of state of recur in the opposite sense when the system returns to its original state.’

Thus, the changes of ice into water and of water into vapor, cause the thermometer to show the disappearance of a very considerable amount of heat which reappears in the change of water into ice and in the condensing of vapors.”
— Antonie Lavoisier (1783), *Memoir on Heat* (co-author: Pierre Laplace) (pgs. 5-6)

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References

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Thermodynamics

In the following set of chapters, we will be covering the basics of *thermodynamics*, which is basic material before one can understand *chemical thermodynamics*, or thermodynamics applied to energy, heat, and work aspects of chemical reactions and processes.

(add)

2#. Carnot

> “Nothing in the whole range of natural philosophy is more remarkable than this establishment of general laws by such a process of reasoning.”
>
> — William Thomson (1849), ‘An Account of Carnot’s Theory on the Motive Power of Heat’

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2#. Clapeyron

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> — Author (date), *Publication*

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36. Joule

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— Author (date), *Publication*

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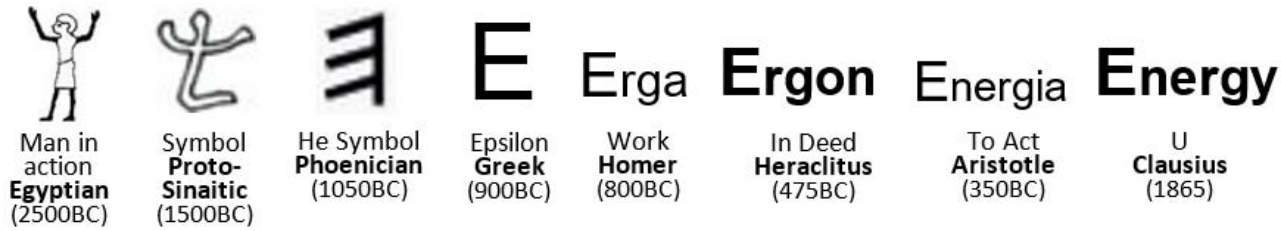
36.1 | E = Sun (Etymology)

The letter 'E', the root letter of the word 'energy', according to Plutarch, from his essay 'De E apud Delphos' (110 ACM), was introduced as the second of the seven Greek vowels, to align symbolically with the 'sun', then known as second of the seven wandering stars: moon, sun, Mercury, Venus, Mars, Jupiter, and Saturn, the 'moon' thought to be the closest and the first, in Greco-Roman cosmology; the following is a synopsis:

> "An anonymous member of the group reports the remarks of a Chaldean visitor who said that the **significance of the letter 'E' lay in its** second place amongst the seven vowels and compared this to the **second place of the sun amongst the seven wandering stars**."
> — Judith Alexander (2018), "Plutarch's 'De E apud Delphos'" (pg. 20)

The letter 'E', prior to its adoption in the Greek alphabet (c.1000BC), derives from the hieroglyph of a man with his arms raised, a person 'in action', or doing 'work' of some sort, i.e. expending 'energy' as we would say:



E words, accordingly, such as energy, existence, engine, equation, experiments, explosion, etc., typically have deep etymological significance, in respect to a person in action, powered by the sun.[1]

#.2 | Subsection Title (date)

Text

Synopsis: (add)

References
1. https://hmolpedia.com/page/Sator_square#E_.7C_Sun
2.
3.

4.
5.

37. Thomson

> "The hardest part of researching this book was untangling the origin of thermodynamics. Scientific progress in any area tends to be a steady refinement of qualitative ideas into analytical laws, but in thermodynamics this journey was unusually tortuous, with the result that academic literature today contains many discrepant opinions on what several pioneers of the subject said, what they thought they were saying, and how important their contributions were. I found no single account that provided a thorough and measured estimation of the whole subject."
>
> — David Lindley (2004), *Degrees Kelvin: a Tale of Genius, Invention, and Tragedy* (pgs. 318-19)

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In Jun 1854, William Rankine, in his "On the Geometrical Representation of the Expansive Action of Heat, and the Theory of Thermodynamic Engines", introduced his so-called 'thermodynamic function', which is said to have adumbrated the concept of entropy.[1]

In May 1854, William Thomson, in his 'On the Dynamical Theory of Heat – Part 5: Thermo-Electric Currents', gives us the following formula:

$$\frac{H_t}{t} + \frac{H_{t'}}{t'} + \frac{H_{t''}}{t''} + \cdots = 0$$

where each H is a quantity of heat, going into or out of the boundary of a system, at the absolute temperatures t, t', t'', etc., at those boundary locations, or in those 'localities, respectively', as Thomson puts things.

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Synopsis: (add)

References

1. http://www.eoht.info/page/thermodynamic+function
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38. Clausius (1865)

> "If we say, in the words of Maxwell some years ago (*Nature*, 1878), that **thermodynamics** is 'a science with secure foundations, clear definitions, and distinct boundaries', and ask when those **foundations were laid**, those definitions fixed, and those boundaries traced, there can be but one answer. Certainly **not before the publication of Clausius**' 1850 memoir 'On the Motive Power of Heat and the Laws of Heat Which May be Deduced Therefrom'. This memoir marks an epoch in the history of physics. Before Clausius, truth and error were in a confusing state of mixture, and wrong answers were confidently urged by the highest authorities"
>
> — Willard Gibbs (1889), 'Rudolf Clausius' (pg. 262)

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26.1 | Internal Energy

Text

26.2 | Work Done BY the System

Text

26.3 | Work Done ON the System

Text

26.4 | Etymology of the Symbol 'S' of Entropy

Having now digressed on the symbol 'Q' for heat, a partial overview of the Egyptian origin of the English alphabet origin, etymological origin of Theta Θ and Delta Δ, in connection thermodynamics, it behooves us to now, at least in passing, touch on the '**S**', origin of entropy, a letter derived from the Greek Sigma '**Σ**', which became the *integral* symbol '∫' in 1675 in the work of Gottfried Leibnitz, meant to be an elongated S, from the Latin word *summa*, which became the mathematical *summation* symbol ∑ in 1755 work of Leonard Euler.

In short, as we will expand on later, the origin of the 'S' symbol for entropy, while this cannot be verified with hundred percent certainty, originated, over the course of a seven month period, in the combined minds of William Thomson (May 1854) and Rudolf Clausius (Dec 1854), Thomson building on Carnot (1834), Clausius building on Thomson.

In May 1854, Thomson, aged 30, in his 'On the Dynamical Theory of Heat – Part 5: Thermo-Electric Currents', gives us the following formula:

$$\frac{H_t}{t} + \frac{H_{t'}}{t'} + \frac{H_{t''}}{t''} + \cdots = 0$$

Where each H is a quantity of heat, going into or out of the boundary of a system, at the absolute temperatures t, t', t'', etc., at those boundary locations, or in those 'localities, respectively', as Thomson puts things.

In Dec 1854, Clausius, aged 32, having read Thomson, in his 'On a Modified Form of the Second Fundamental Theorem in the Mechanical Theory of Heat', gave us the following nearly equivalent formula:

$$N = \frac{Q_1}{T_1} + \frac{Q_2}{T_2} + \frac{Q_3}{T_3} + \ldots$$

where heat Q and absolute temperature T are defined exactly as Thompson, but where N is called the equivalence value of all uncompensated transformations, which he says can be 'summed' up as follows:

$$N = \sum \frac{Q}{T}$$

Clausius also says that if we integrate over the entire cycle, namely the Carnot cycle, as we will explain, the formula becomes:

$$N = \int \frac{dQ}{T}$$

In 1865, Clausius, building on previous publications, comes to define the differential units of heat dQ going into or out of the system, divided by the absolute temperature, measured at the point of transmission of heat, as Thomson had done, by the new symbol dS, as follows:

$$dS = \frac{dQ}{T}$$

which, as Clausius says, if we conceive this equation to be integrated for any reversible process whereby the body can pass from the selected initial condition to its present one, and denote at the same time ty S_0 the value which the magnitude S has in that initial condition, we arrive at the following equation:

$$S = S_0 + \int \frac{dQ}{T}$$

This 'new' equation, as Clausius says, is to be used in the same way for determining S as equation the previous equation #59 (Clausius, 1865) was for defining U, which is repeated below:

$$U = U_0 + Q - W$$

In modern notation, this would be represented as:

$$\Delta U = Q - W$$

Clausius goes on to clarify that this new S differential dS is an 'exact' differential, whereas the old Q differential dQ is an 'inexact' differential, which in modern notation, translates as follows:

$$dS = \frac{\delta Q}{T}$$

Where the lower case 'δ' means *inexact* and the English lowercase letter 'd' means *exact* differential, which is a mathematical derivation that originated in the so-called *Euler reciprocity relation* (c.1739), which Clausius does not cite directly.

In any event, with respect to the etymology of 'S', Clausius, without stating this directly, choose the symbol '**S**', in upgrade to his former symbol '**N**', and prior to that Thomson's symbol '**0**', as best as we are

able to discern presently, as having the meaning of the *summation* 'Σ' (Euler) or *summa* integral '$\int$' (Leibnitz), of the sum of all 'transformation equivalents' in one Carnot cycle. This is about as simply as we can state things, presently, baring chapter progression.

We will, however, directly point out that Maxwell, following his published *misunderstandings* of what entropy was exactly, per his misaligned understanding learned via his readings of Peter Tait, after having learned the basic overall correct understanding of what entropy was, namely in terms of sums of 'transformation equivalents', i.e. sums or integrals of 'δQ/T' units, going into or out of a system, stated the following very discerning comment:

> "By the introduction of the expression 'without compensation', verses 'of itself', combined with a full interpretation of this phrase, the statement of the **second principle** [second law], namely: that 'heat cannot *without compensation* pass from a colder to a warmer body', **becomes complete and exact**; but in order to understand it we must have a previous knowledge of the **theory of transformation-equivalents**, or in other words ***entropy***, and it is to be feared, that we shall have to be taught thermodynamics for **several generations** before we can expect **beginners** to receive as *axiomatic* the theory of entropy."
>
> — James Maxwell (1878), 'Tait's Thermodynamics' (pg. #)

In other words, according to quick mind of Maxwell, it should have taken us several generations, or about 99 to 132 years, assuming 33-years per generation (3 to 4 generation) since the publication of 'Tait's Thermodynamics' article, or the years 1877 to 2010, for humans to get an axiomatic understanding of entropy, for *beginners*, in respect to the theory of transformation equivalents. The year, presently, at the penning of this chapter, is 2020 years after Christ myth (YAC), and we are still ignorant, below the *beginner* level.

This can be evidenced, as has been done in multiple YouTube videos, by going onto the street and asking any random 10 people what 'entropy' is? On average, about two out of ten will have an answer, telling you that it is the tendency towards disorder, maximal chaos, or the heat death end of the universe, or something along these lines. One of the aims of penning this publication is to remedy this ongoing cultural idiocy.

Clausius, to conclude, and summarize, employed the letter 'S', as the symbol for *entropy*, which he alternatively called the 'transformational content' of the body, to mean the *summation* 'Σ' (Euler) or *summa* integral '$\int$' (Leibnitz) of all *transformation equivalents*, in one Carnot cycle.

"Clausius proposes that the transformation of mechanical energy into heat be taken as 'positive', that the heat into mechanical energy as 'negative'."
— Donald Cardwell (1971), From Watt to Clausius (pg. 265)

"Clausius' 1850 equation: U = Q – AW, is defined such that Q quantifies the heat 'gained by the system' (positive value), while W quantifies the 'work done by the system' (positive value), such that a system gains energy for positive Q and loses energy for positive w (by doing work)."
— Robert Hanlon (2020), Block by Block (pg. 117)

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26.3 | Entropy

Text

Synopsis: (add)

References

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43. Lewis (1923)

“.”
— Author (date), *Publication*

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“While I have flirted with many problems, I was for many years pretty loyal to the main task which I had set for myself, namely, to weave together the abstract equations of thermodynamics and the concrete data of chemistry into a single science. This is the part of my work in which I feel the greatest pride, partly because of its utility, and partly because it required a considerable degree of experimental skill. That part of my work therefore which has given me the greatest amount of personal satisfaction was the study of the free energy of formation of the most important compounds and, in particular, the electrode potentials of the elements.” — Gilbert Lewis (1928), “Letter to James Partington”

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References

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100. Religion

> "The surest way of extirpating all the heresies, and of destroying the kingdom of the antichrist, and of establishing **'true religion'** in the hearts of men, is by perfecting a **true system of natural philosophy**."
> — Roger Bacon (c.1275), *Publication* (pg. #)

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Synopsis: (add)

References

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107. Roegen-Samuelson Copper Economic Model (1971)

“.”

— Author (date), *Publication*

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In 1934, Romanian Nicholas Roegen, after having completed his undergraduate degree in mathematics, at the University of Bucharest, Romania, and his PhD in statistics at the Institute of Statistics, Sorbonne, Paris, where he absorbed the philosophy of science ideas of Blaise Pascal, Ernest Mach, Henri Bergson, and Karl Pearson, accepted a scholarship, via the Rockefeller Foundation, to study at Harvard, whereat he encountered economist Joseph Schumpeter, who became his guiding mentor, whose work then was on business cycles and evolutionary economics. Roegen stayed in the US for a year before return to Romania, during the course of which he met: Irving Fisher, Friedrich Hayek, and Einstein.

In 1971, Roegen, skipping forward four decades, came to pen his *infamous*, as we correctly view things, or *famous*, as he is viewed by many in the pop culture presently, *The Entropy Law and the Economic Process*, wherein he opened to the following:

> “To some, the term ‘entropy’ may seem esoteric. Once it was, but now it is becoming increasingly popular in one field after another. What should now give us reason for concern in meeting the term is the fact that its meaning varies substantially, at times even within the same domain of intellectual endeavor. In *Webster's Collegiate Dictionary* alone we find **four distinct entries** under ‘entropy’. In part, this situation reflects the most unusual history of the *entropy law*, continuously punctuated by celebrated controversies, not all dead yet. In view of the confusion which has accumulated in some quarters, a preliminary survey to contrast the main meanings of ‘entropy’ may prove useful even for the reader already familiar with some of them.
>
> There is, first, the original meaning with which ‘entropy’ was introduced more than one hundred years ago by the German physicist Rudolf Clausius. This meaning is grounded in a bedrock of physical facts **[Yes]**. All other meanings constitute a separate category that stands in opposition to it **[?]**. These are related in a purely formal way to a simple algebraic formula which is the cloak under which ‘entropy’ is now becoming familiar to an increasing number of social scientists. Just recently, the term—with such a formal meaning—was brought within the economist's field of vision by the invitation to include a special ‘theory of information’ (Theil, 1967) in his tool box **[No]**.
>
> The physical concept is **generally judged to be quite intricate [Yes]**. If we take the word of some specialists, not even all physicists have a perfectly clear understanding of what this concept exactly means. Its **technical details are, indeed, overwhelming [Yes]**. And even a dictionary definition suffices to turn one's intellectual curiosity away: ‘a measure of the unavailable energy in a closed thermodynamic system so related to the state of the system that a change in the measure varies with change in the ratio of the increment of heat taken in to the absolute temperature at which it is absorbed’. All this does not alter the fact that the **nature of most thermodynamic phenomena is so simple [?]** that the layman may grasp the concept of entropy in its broad lines without much difficulty.
>
> Let us take the case of an old-fashioned railway engine in which the heat of the burning coal flows into the boiler and, through the escaping steam, from the boiler into the atmosphere. One obvious result of this process is some *mechanical work*: the train has moved from one station to another. But the process involves other undeniable changes as well. To wit, the coal has been transformed into ashes. Yet one thing is certain: the **total quantity of matter and energy has not been altered [No]**. That is the dictate of the ‘law of the conservation of matter and energy’ **[No]** —which is the ‘first law of thermodynamics’ **[No]** and which, we should stress, is not in contradiction with any of the laws of mechanics. The conclusion can only be that **the change undergone by matter and energy must be a qualitative change [No]**.

> At the beginning, the chemical energy of the coal is free **[No]**, in the sense that it is available to us for producing some mechanical work. In the process, however, **the ‘free energy’ loses this quality [No]**, bit by bit. Ultimately, it always *dissipates* completely into the whole system where it becomes **‘bound energy’ [No]**, that is, energy which we can no longer use for the same purpose. To be sure, **the complete picture is more involved [Yes]**. And in fact, the merit of the introduction of entropy as a new variable of state lies precisely in the analytical simplification and unification achieved thereby. Even so, the other, more intuitive concepts of free and bound energies have never lost their transparent significance. For, in a broad yet substantive perspective, **entropy is an index of the relative amount of bound energy in an isolated structure [No]** or, more precisely, of **how evenly the energy is distributed in such a structure [No]**. In other words, ‘high entropy’ means a structure in which most or all energy is bound **[No]**, and ‘low entropy’, a structure in which the opposite is true **[No]**.”
>
> — Nicholas Roegen (1971), *The Entropy Law and the Economic Process* (pgs. 4-5)

The above description is confused beyond measure. Granted, we will conceded, Rogen was a mathematician, by training, never having an educational contact with physics, chemistry, or thermodynamics, let alone chemical thermodynamics, wherein ‘free energy’ and ‘bound energy’ were coined, specifically in Helmholtz’s 1882 *On the Thermodynamics of Chemical Processes*, based on the earlier work of Gibbs’ 1876 *On the Equilibrium of Heterogeneous Substances*. As the saying goes: ‘take one step forward, three steps back’. Here, we are forced to take one step forward, at least ten steps back, to say the least.

This entire confused mess of convoluted misunderstanding, resulted in the so-called equally-confused concept of ‘material entropy’, the mis-understood idea that natural recourses, such as coal, oil, copper, are ‘free energy’, and that according to the ‘second law of matter-energy’, as Roegen incorrectly phrases things, these will transform into ‘bound energy’ or waste gases, or something along these lines? These simplified to the point of backwards incorrectness, has many followers in the modern day.

In 1989, Paul Samuelson, to cited a prevalent example, in his ‘Gibbs in Economics’ talk, at the 150th birthday Symposium on Gibbs at Yale, after praising Roegen’s *The Entropy Law and the Economic Process*, and his surrounding work, as being deserving of a Nobel Prize in Economics, goes on go gives us the following economic model, employing Roegen’s material entropy model of copper:[1]

> “Let me close on a serious note. Nicolas Georgescu-Roegen has well said that the, logo for economics should be an hourglass and not a frictionless pendulum. To model this insight, I ignore the niceties of primers on thermodynamics. Instead I contrast two economic models.
>
> Model #1, a stationary population working on specified land, exposed to the sun's energies, produces a steady state of consumable output of bread. This is the orthodoxy Georgescu-Roegen wants to go beyond.
>
> Model #2 is like Model #1 but to produce our daily bread we need, along with labor and land, an input of copper. Copper can be mined by labor but the faster you mine its limited seams the greater your incremental labor cost; and, the more you have depleted the mine of rich copper veins inherited from way back, the greater the needed labor.
>
> It must be obvious without writing down the system's equations that no steady state of positive bread consumption is possible with a specified constant total of labor and land. The more copper that has been 'dissipated' in the past from its rich seams, the more labor must be switched out of bread production. The system runs downhill in bread production as, so to speak, the entropy of dispersed copper concentrations grows. If copper has no effective substitutes, the addition of produced capital goods to the model does not change its declining fate at all.
>
> Admittedly, no steady state is possible in this Club-of-Rome model of exhaustible resources. The **ball, however, is in the court** of those who believe that Clausius-Gibbs formulisms can give us more insights than are already in this ad hoc model.”
>
> — Paul Samuelson (1989), ‘Gibbs in Economics’ (pg. 266)

Here, firstly, Samuelson, without saying so, as absorbed the Roegen model that copper is 'free energy', and that according to the 'material entropy' scheme, it will, over time, according to thermodynamics, transform into 'bound energy'?

Secondly, Samuelson, being a grandson of Gibbs, as he refers to himself, believes that conjugate variable pairs apply to economic systems, BUT only in the form of mathematical isomorphisms. Here, we will note this this 'ball is in Clausius court', comment, as opposed to the 'Shakespeare side of the tennis court', in the Charles Snow definition of the two cultures, comes after, in 1938, Edwin Wilson, one of the only handful of protégé's of Gibbs, suggested to Samuelson that he try to employ Gibbs equation 133, shown below, in the form of conjugate variable pairs, as a basis for a model of an economic system:[2]

$$U - TS + PV - M_1m_1 - M_2m_2... - M_nm_n$$

The entire situation makes one shake their head, to say the least.

References

1. Samuelson, Paul. (1989). "Gibbs in economics", in: *Proceedings of the Gibbs Symposium*, Yale University, May 15-17 (editors: D.G. Caldi and George Mostow) (pgs. 255-68). American Mathematical Society.
2. http://www.eoht.info/page/equation+133
3.
4.
5.

#. Title

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Chapter point: (add) [length: #-pgs]

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#. Homework Problems

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Postscript | Solidification

Of note, some of the chapters herein may, to the discerning reader, if there be such a thing, may seem decisively short and abrupt; say as compared some of the content of the four-million plus word-filled *Hmolpedia*.

To explain, and to keep everyone in the loop, the author's heart, or 'Jb' as he Egyptians named things, as explained in the first chapter, has been going, owing to 'arrythmia' condition, wherein conflicting electrical activity, shuts off blood, for about the last six years, or since circa 59 AE (2014 ACM). This is coming from someone who ran a 5-min mile, qualified for the Boston Marathon, ran a 40-mile 15% incline run in a sub 12-range, and nearly completed a sub 10-hour Ironman. The author has been aware of this for some time, as it was once mentioned in passing at age of about 20±.

It is a general rule, stated somewhere, that each 'thing' has an existence window correlative to the rate of its heart beat, think humming birds (3-5 years) vs elephants (60-70 years). As the author has been, for some time, 1991-present, burning the 'wick at both ends', as the saying goes, he is closer to the humming bird, than the elephant.

Hence, after two blackouts, waking up in hospitals, and two surgeries, the goal has be shortened, and the present focus, herein, is to get past the 1,067 'will to power fragments' level of Nietzsche, prior to him losing his mind, wherein in the last of these fragments he was grappling with thermodynamics.

In short, some chapters will be short, because they are trivial but necessary stopping points, e.g. the Savery chapter, whereas others will be short, but are in need of being longer, owing to the density, e.g. Gibbs, Clausius, Euler, Legendre, etc., and or short owing to lack of available translations, e.g. Winiarski, Bazargan, etc. The author desires to 'see' a basic outline of the subject of *chemical thermodynamics applied to humans*, however crude it may be, and however ideal author would have liked or envisioned to see the subject presented, in his heart-working-correctly powerful mind-flow years of 1991 to 2013, wherein 4-7 hours of sleep would, on average, yield 3 to 14 hours of powerful, daily, research, writing, and thinking. It would seem advisable, accordingly, given the extant situation, to have a stitched outline of a 100 or so connective chapters, exact or crude, then 1,067 unconnected fragments. The 5,300+ articles of Hmolpedia, in some sense, are Nietzschean fragments to the finalized vision of *human chemical thermodynamics*, derived, pure, and applied.

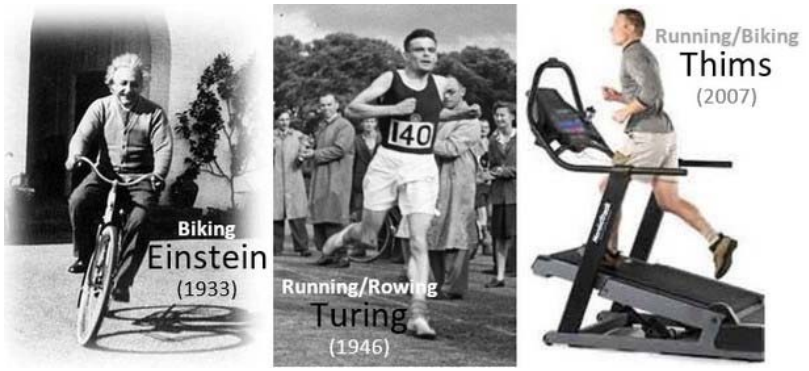
Ideally, the completion of a textbook on the fundamental principles of 'human chemical thermodynamics', geared to graduate level students, in applied social, economic, and history, etc., thermodynamics, was slated for years into the future [c.2030], therein allowing for more research and digestion of material before solidification of subject matter. Health issues, in respect to recent growing 'heart arrythmia' complications, however, have worked or acted to precipitate, i.e. bring solidification of, the ephemeral realization of said topic in a single book format, however crude and or incomplete.

Chronologically, in c.2010 the author found it difficult to do his typical fast-paced 38-mile roller blade trip along Lake Shore Drive, from Hollywood Boulevard to Rainbow Beach, having to lay down on the grass on the return trip for several minutes. In Jun 2013, while lecturing in Romania, the author, a former age 20-something Boston marathon qualifier, found it curiously difficult to run up the 1,480-steps of Poenari Castle, aka Dracula's castle, in one continuous spurt, and had to pause multiple times.

In 2014, the author, in the weeks of his physico-chemical sociology debates with Mirza Beg, began to notice fainting spell like moments.

In Sep 2015, the author, while at the gym, completely **'blacked out'**, while running on the treadmill (at his normal 7.8 mph / 15% incline pace), coming to several hour later in the hospital, owing to what turned out to be arrythmia of the heart. This was a HUGE turning point. Two separate ablation procedures resulted, one in 2015 another in early 2018 resulted. These seemed to abate the issue, in some sense.

On 7 Nov 2018, a fourth semi-black out had occurred, resulting in one-hour of resting immobility, therein preempting the author, following reaction extent end visions and planning, in a worst case scenario, to get his thoughts down on the subject of 'human chemical thermodynamics', in one coherent form, **before his reaction existence comes to an end**, presuming time is short in respect to existing as a 'working' powered CHNOPS+26 element thing (note: a non-working powered CHNOPS+26 element thing, e.g., could be a vegetative person following a stroke, whose existence, therein, becomes *endergonic*, i.e. Gibbs energy absorbing, such as being kept powered, aka 'alive', by family and or life-support devices), so as to go beyond the fate of Nietzsche (1889) who supposedly had a nervous breakdown and his mind amid assembling his energy based 'will to power' fragments; John Tukey (1966) whose Gibbs energy based 'attitude change' model of transition states only made it to the verbal discussion level; or Adriaan Lange (2009), whose health issues barred him from completed his Gibbs energy based evolution model of things, at the social level, in English (he published only in Afrikaans, and separate online blogs), as a book, something he had discerned, in his mind, as a physical chemistry professor, while teaching student standard physical chemistry.



An image Einstein biking, Turing running, and Thims (mock) running, from the Genius and Exercise article of Hmolpedia.

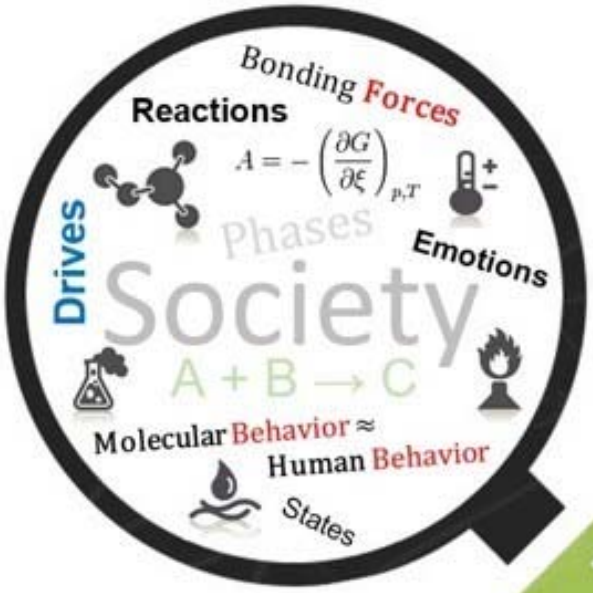
While the author had planned on completing a five-volume *Smart Atheism for Kids*, some of which shown adjacent, replete with religio-mythology decoding, e.g. how Noah's Ark and Manu's boat are both rescripts of Nu's flood, Abraham and Brahma are both rescripts of Ra the sun god born out of Nu, etc., based on the content of the previous atheism for kids class, some 300+ draft pages of which having been completed by 2017, getting stalled out on a few details of the Roman era recension (100-500 ACM) of the Osiris-Horus to Jesus rescript, along with absorbing more works of the great social newtons, e.g. Pareto, Buckle, Adams, Schopenhauer, Hobbes, Spinoza, Winiarski (needs English translation), etc., and religio-mythology scholars, e.g. Bruno, Godfrey Higgins, Massey, Budge, etc., with heart issues seemingly increasing in frequency, a move to at least get the basic outline of human chemical thermodynamics, in condensed format, in 740-pages or less (max 8.5x11-inch sized page limit per book at Lulu), thematic in powerfulness to Baron d'Holbach's great masterpiece *The System of Nature*, before reaction existence ends, would seem to be of pressing order.

Synopsis: (add)

Index

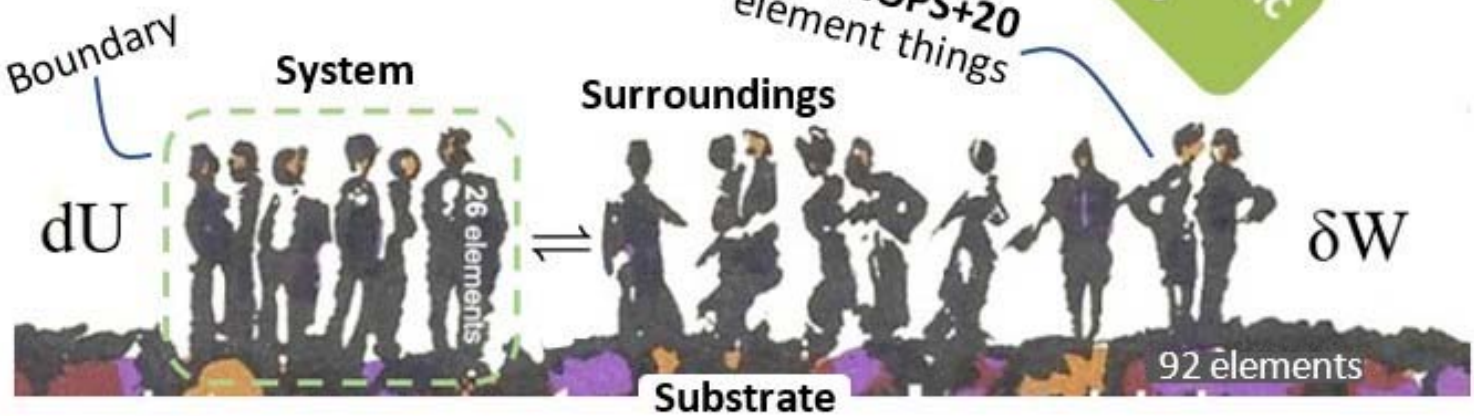
(add index of names and terms)

Chemical thermodynamics, Humanities, Sociology, Economics, History, Philosophy, Government, Ethics, Politics



Thermodynamic Lens

CHNOPS+20 element things



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